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COMMONWEALTH OF MASSACHUSETTS

SUMMARY OF WATER QUALITY

1996

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TITLE: COMMONWEALTH OF MASSACHUSETTS
SUMMARY OF WATER QUALITY 1996

DATE: DECEMBER 1997

APPROVED BY:

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Division of Watershed Management

Arleen O'Donnell, Asst. Commissioner
Bureau of Resource Protection

COMMONWEALTH OF MASSACHUSETTS

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1996

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WORCESTER, MA

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DECEMBER 1997

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1.0 EXECUTIVE SUMMARY

1.1 The 305(b) Process

The Federal Clean Water Act (CWA) establishes a process for the development of information concerning the quality of the Nation's waters and reporting this information to the Environmental Protection Agency (EPA) and the U.S. Congress. Each state must develop a program to monitor the quality of its surface and groundwater and prepare a report every two years describing the status of water quality. This process, referred to as the 305(b) process, is the principal means by which the EPA, Congress, and the public evaluate water quality, the progress made in maintaining and restoring water quality, and the extent to which problems remain.

In 1988, EPA began the implementation of an automated data management system to record the results of water quality assessments and manage newly-required assessment information under the Clean Water Act of 1987. The Section 305(b) Waterbody System (WBS) is under implementation in Massachusetts and attempts to improve consistency in determining use support, measuring total state waters and assessing trends. The effort to implement these new guidelines in the 1992 report makes that report the baseline for trend analysis within the state, and for comparison with other states. This year's report continues that effort.

1.2 Water Quality Assessments

Waters are assessed to determine the levels of support for specific designated uses. The CWA establishes "fishable and swimmable goals" for all the nation's surface waters. For the purposes of this report the national goal uses are:

1. Aquatic life: a suitable habitat for the survival and reproduction of a native, naturally diverse community of aquatic flora and fauna.

2. Swimming - recreational activities with prolonged and intimate contact with the water with a significant risk of ingestion of water.

3. Fish Consumption - consumption of the edible portions of marketable fish or shellfish and the recreational use of fish, shellfish and other aquatic life or wildlife for human consumption.

4. Secondary Contact Recreation - recreation in which contact with the water is either incidental or accidental such as fishing, boating and shoreline activities.

In addition to the national goal uses this report contains separate sections on shellfishing and public water supplies. Wetlands and groundwater information also are reported.

The level of use support is rated in five categories:

1. Full Support - all designated uses are fully supported.

2. Threatened - all designated uses are fully supported but one or more uses may not support in the future, unless some action is taken.

3. Partial Support - one or more of the designated uses are partially supporting.

4. Non-support - one or more of the designated uses are not supported.

5. Not Attainable - the use is not achievable because of natural or irreversible constraints.

It is important to realize that not all waters are assessed. Information is available only on a small subset of the state's waters and this subset is biased toward areas with known water pollution problems. When assessments are made the type of information used to make the assessment is also recorded:

1. Monitored Assessments - are based on recent monitoring data.

2. Evaluated Assessments - are based on qualitative information or monitored data more than five (5) years old.

In each assessment the pollutants that degrade water quality (causes) and the sources of these pollutants are also recorded. Common causes of non-support include pathogens, toxics, nutrients and turbidity. Sources include municipal and industrial discharges, combined sewer overflows and various nonpoint sources such as stormwater runoff and contaminated sediments.

1.3 River Assessment

This report contains the assessment of 1,307 river miles of the 8,229 total river miles in the state. The 84% of the miles that are unassessed consist largely of small headwater streams and minor tributaries with no known or suspected pollution problems. From a point source pollution perspective these streams could be evaluated as supporting their uses; however, the enigmatic nature of nonpoint source pollution prevents this assumption from being made.

The 1,307 river miles assessed in this report comprise the major mainstream rivers in the state and those tributaries with major point sources of pollution. These rivers are the most visible and flow through the major population centers of the state. These rivers have been the focus of cleanup efforts over the past 25 years. Their condition reflects the magnitude and nature of future cleanup efforts needed.

The river clean up program has enjoyed enormous success. Nearly 70% of the river miles assessed now support aquatic life, swimming and boating; with the qualification that half of the swimmable miles still experience some intermittent problems. The significance of this information is that swimming and fishing in most of these waters would have been unthinkable 25 years ago. This highlights the success of the industrial and municipal point cleanup program. In particular, the state's Municipal Facilities Program directed nearly 4 billion dollars of federal and state funds since 1967 in achieving this progress. Currently there are 139 publicly owned treatment works that treat over a billion gallons of sanitary and industrial wastewater each day and serve 70% of the state population. Industrial and municipal point sources no longer cause major impacts in Massachusetts rivers.

The completion of the cleanup of rivers will require targeting different sources of pollution. Nonpoint source pollution from stormwater runoff, combined sewer overflows, and toxic contamination in sediments (largely historical) prevent the remaining river miles from meeting their goal. Bacteria impact over half of the rivers assessed and are largely attributable to stormwater runoff and combined sewer overflows. The CSO problem is being aggressively enjoined by ongoing abatement programs. The larger problem of a nonpoint source abatement requires new approaches to remediation that are incorporated in the Watershed Approach. Toxic pollutants contaminating sediments and moving up the food chain into fish flesh poses another problem

demanding nontraditional solutions. The contamination appears to be largely historical. Better definition of the nature and extent of the problem are needed before suitable abatement measures can be selected.

Isolated cases of municipal and industrial point source problems still persist which point to the importance of compliance and enforcement of NPDES permit sites as well as the more global issue of ensuring proper operation and maintenance of existing facilities.

Figure 1 provides a graphic summary of the number of river miles assessed, level of overall use support and a breakdown of the percentage of assessed miles based on individual use.

Figure 2 illustrates the causes of impairment and potential sources versus the percentage of miles assessed.

1.4 Lake Assessment

The lake assessment provided in this report is heavily biased by the Department's current lake survey methodology. In past years the Department's lake monitoring program was designed to detect eutrophication problems (from nutrient enrichment increasing aquatic plant and algal growth) for the purpose of selecting lakes for preservation or restoration activities. Lake surveys are now synoptic in nature and are designed for documenting aquatic plant cover and presence of non-native aquatic plant species. Nutrients, pathogens, dissolved oxygen, and toxics, among other parameters remain a potential concern requiring additional monitoring where resources allow.

Twenty percent of the total 151,173 acres of lakes are assessed for this report. Figures 3 and 4 provide a graphic summary of the lake assessment results. Of the nearly 644 lakes that have been surveyed by the Department's program at some time 391 are assessed this year for readily observable conditions. Almost three quarters of these assessments are considered monitored. Although these numbers represent an increase in lake monitoring activities over previous years, it also represents an evaluation of conspicuous conditions thus allowing for a limited assessment of the individual national goals. Source identification of pollutants is not presently part of this synoptic program. It is hoped that the watershed approach will assist the Department in identifying many of these potential sources in the coming years.

Less than a quarter (23%) of the assessed lake acreage support all of their uses. About a quarter (24%) of the acreage was not supporting at least one of the designated uses. The remaining acreage rated as partial support. Since the last reporting period this represents a decrease in the percentage of assessed lake acres fully supporting all uses.

Of the individual national use goals only secondary contact recreation was well supported (59%). Although other uses indicated much lower levels of full support, they also exhibited a high percentage of acres not evaluated in this reporting cycle. These changes reflect the shift in focus of the Department's lake monitoring described above. None of the uses had a high percentage of lake acres listed as non-support but more than half (51%) of the acreage assessed only partially supported the aquatic life use.

The causes of non-support include the imbalancing of macrophyte communities due to the presence of non-native species, the proliferation of aquatic plants in general, and excess metals (associated with bioaccumulation impacts in fish). The sources of these stressors are largely unknown, although nonpoint

sources, including stormwater runoff and on-site wastewater systems, are largely suspected. Some of these potential sources, such as on-site wastewater treatment systems, are being addressed through the development and implementation of new regulations which now require periodic inspections and upgrades where systems are found to be failing. It is estimated that approximately 6000 systems will now be inspected annually however the extent of improvement this activity has on future water quality conditions is yet unknown.

The above lake assessment summary does not include the assessment of Quabbin Reservoir. The lake is 25,000 acres and therefore almost equal to the rest of the assessed acreage. Quabbin Reservoir is assessed as supporting all of its national goal uses except fish consumption. High levels of mercury in sport fish flesh is the subject of an ongoing study.

Acid precipitation is also a continuing concern in Massachusetts lakes. Data were collected prior to 1994 through the Water Resources Research Center's Acid Rain Monitoring (ARM) Program at the University of Massachusetts, Amherst, on over 2000 lakes. They indicated that 515 lakes were rated as "critical," 398 as "endangered," and 432 as "vulnerable" with respect to acid precipitation.

1.5 Marine Assessment

Marine waters can be divided into: 1) harbors and estuaries; and 2) open ocean areas. Water quality information is available for many harbors and estuaries, particularly the more populated areas with ongoing or planned pollution abatement projects. Data is scarce for open ocean areas. The Department's waterbody system covers 218 square miles of harbors and estuaries. It does not contain open ocean areas. The Division of Marine Fisheries (DMF) assesses approximately 2,700 square miles of marine waters for shellfishing including nearly all of the Department's assessed areas. Although not intended for this purpose, The DMF area is used as a rough approximation of total marine waters so that the Department's assessment can be put in relative perspective. More accurate estimates of total coastal waters may be available for future reports.

The Department's assessment is heavily biased toward areas that were previously polluted. Over half (56%) of the assessed marine waters did not support one or more of their designated uses. Since the Department's assessment concentrates on near-shore areas of harbors and bays the overall quality of coastal waters is better than one would observe looking only at the Department's data. DMF's data covers a much larger portion of open ocean waters. Their data indicate only 9% of the coastal waters assessed did not support shellfishing. Since shellfishing demands a high level of water quality it can be assumed that the overall quality of coastal waters is underestimated by this assessment.

The assessment shows that marine waters are lagging behind the river cleanup. Only 27% of the assessed waters fully supported their uses. However all the major urban areas on the coast are either in facilities planning or construction phases of new clean up efforts. Foremost among these is a massive project to cleanup Boston Harbor. Sewer system rehabilitation and improvements in sludge handling have already made positive impacts on the waters of Boston Harbor.

When uses are examined individually half (50%) of the assessed waters support aquatic life fully. Eighty-seven (87%) of the waters fully or partially support primary and secondary contact recreation.

The major cause of nonsupport in marine waters is bacterial contamination. This is the cause of impacts in over two-thirds of the waters assessed. The predominant sources of these bacteria are combined sewer overflows and stormwater runoff although other sources may contribute. Cleanup of combined sewer overflows is underway in many locations. Cleanup of stormwater runoff will undoubtedly lag behind until regulatory procedures are better established. New stormwater regulations are currently under development to address this issue.

Toxic contamination of marine waters is demonstrated by areas of contaminated sediments in Boston Harbor, Quincy Bay, areas of the North Shore and Buzzards Bay. These are areas of historical pollution and pose special problems for cleanup efforts; but experience gained in the on-going Buzzards Bay cleanup may provide insight for future efforts.

Municipal point sources impact 34% of the waters assessed. These impacts include nutrient enrichment and toxicity from ammonia. Facilities planning in the major urban areas should correct these problems.

Approximately 40% of the waters assessed received impacts from unknown sources. The complexity of marine hydrology makes it sometimes difficult to attribute cause and effect. This fraction will have to be reduced in order to better sort out the relative contributions of point and nonpoint sources and better resolve the number and types of nonpoint sources. Figure 5 and 6 provide a summary of the assessments related to marine waters.

1.6 Other Highlights and Concerns

1. The Watershed Approach

   The implementation of the Watershed Approach to resource management represents a significant change in implementing regulatory programs. Twenty-seven basins have been geographically defined for management purposes and scheduled on a five year program. Under this schedule water quality sampling will now be targeted at approximately 20% of the basins in any given year and sampling will be targeted at priority issues established by the watershed teams. Government agencies will form partnerships with watershed stakeholders to cooperatively identify problems, define solutions and implement actions. Limited resources are better targeted to watershed priorities and toward comprehensive solutions. Sound science and public impact are used to guide the entire process.

   The future impact of this approach on the 305(b) assessment process will be to allow additional information sources to be utilized in making more detailed and informed assessments on individual watersheds and subwatersheds. It is anticipated that 305b assessments in the future reporting cycles will benefit from the use of quality assured monitoring and reporting efforts of citizen based groups. In particular, it is anticipated that the identification of the sources of impairment will be enhanced considerably as a result of regional and local input on critical issues.

   An example of this type of coordinated effort is the recent Neponset River Watershed pilot program. This pilot program was a collective effort of hundreds of citizens, business people, municipal officials, non-profit organizations and government agency personnel which was designed to identify and resolve critical issues of concern within the

Neponset watershed. Part of that effort was the implementation of a targeted monitoring program to document current water quality and biological conditions of the water resources within the basin. Attachment no.1 of this report provides the graphical results of the Neponset monitoring program. It is provided in this report as an example of the type of effort that the Commonwealth is working towards in the future.

The future reporting of 305b assessments will also change by focusing on the group of watersheds that were actively being monitored in the two years prior to the 305b reporting cycle. Thus, the 1998 305(b) Report will include updated information on the following watersheds: Buzzards Bay, Deerfield, Ipswich, Islands, Millers, Shawsheen, Concord, Farmington, South Coastal, Taunton, and Westfield.

2. Changes in Surface Water Monitoring

The surface water monitoring program of the 1970's focused on conventional pollutants and point sources of pollutants. In the 1980's the emphasis shifted to the investigation of nutrient problems and increased baseline monitoring of lakes. Toxic pollutants were investigated and techniques were refined to better detect them. The monitoring program of the 1990's is now shifting focus to nonpoint sources of pollution. Summertime, low flow sampling is augmented by seasonal and rainfall event sampling in order to characterize nonpoint source loading. And, biological communities are increasingly being monitored (in place of traditional chemical monitoring) as integrators of multiple environmental stressors.

3. Projections and Trends in Water Quality

The monitoring program samples a relatively small and biased subsample of the total waters of the Commonwealth. Generally, less than 20% of the rivers and lakes and less than 10% of the marine waters are assessed during each reporting period. The waters that are assessed tend to be those with known or suspected pollution problems; therefore, the data presented in this report cannot be projected reliably to water quality statewide. Furthermore, because of the increasing sophistication of the monitoring program, more pollution problems (e.g., nutrients, toxics, nonpoint sources) have been uncovered in recent years. Using the 305b report for trend analysis is misleading because apparent decreases in water quality may in fact reflect more complete information rather than an actual downward trend in water quality.

For example, a comparison of the summary information from the last three 305b reports shows an apparent downward trend in water quality for assessed rivers:

Percent Assessed River Miles Fully Supporting

Use	1992	1994	1996
Overall Use Support	40%	32%	28%
Aquatic Life Support	75%	70%	63%
Primary Contact - Swimming	81%	46%	39%
Secondary Contact	82%	74%	69%

Among the factors why the apparent downward trend in water quality is misleading are:

- Historically only conventional pollutants were monitored - more recent monitoring includes both conventional and toxic pollutants

- Historically dry weather conditions were monitored - more recent monitoring includes both dry and wet weather conditions

- Historically monitoring was focused on the water column - more recent monitoring includes sediment and fish flesh (where toxic pollutants accumulate)

- New and/or modified water quality standards as well as lower detection limits on chemical analysis

These factors, combined with changes in assessment methodologies, most likely account for the apparent downward trends in water quality.

While it is difficult to establish trends in water quality quantitatively using the summary information from the 305b report, it is possible to examine changes based on qualitative measures. By examining only conventional pollutants in dry weather conditions in the water column for the past 25 years, 67% of the rivers are considered fishable (suitable for aquatic life), 69% are considered swimmable. Given that these same rivers were grossly polluted 25 years ago, the comparison reveals that great strides have been made in improving water quality. The point source controls that have been put in place have improved water quality in 2/3 of the assessed river miles. At the same time, however, the comparison also reveals that in order to clean up the remaining 30% of the river miles assessed attention needs to shift to not only include point sources, but nonpoint sources and toxic pollutants.

4. Fish Tissue Contamination

The monitoring of fish tissue for contamination over the last several years has been a new initiative but data collection has not been extensive. However, DEP, DPH and DFWELE are cooperating in an assessment program to protect the public from ingesting harmful quantities of toxic pollutants in contaminated fish and shellfish. Fifty-nine (59) advisories have been issued to limit consumption. Forty-one (70%) of these advisories are due to mercury contamination and fifteen (26%) due to PCB contamination. The source of the mercury is believed to be atmospheric transport and deposition. The source of the PCB's have been traced to historical sources no longer active. Because of the perceived risk from mercury contamination a precautionary statewide advisory has been issued recommending that pregnant women refrain from consumption of freshwater fish from Massachusetts Waterbodies until more information can be gathered.

5. Shellfish

Statewide 1,745,594 acres of shellfish growing waters were classified by the Division of Marine Fisheries (DMF). Nearly 78% of these shellfish growing waters supported the use, 9% did not support the use and 12% were not assessed (Classified by DMF as under Management Closure). The shellfish assessment covers an area more than 10 times greater than the

marine waters assessment based on water quality monitoring alone; therefore, the shellfish classification information better indicates water quality conditions of coastal waters statewide. Coastal waters of the North Shore and Boston Harbor account for the large majority of waters not supporting shellfishing (131,359 of 163,053 shellfishing acres not supporting). In Mount Hope Bay, all 6,812 acres of shellfish resources are not supporting. While not showing on a percentage basis, contamination of areas previously thought of as pristine (such as Cape Cod and the Islands) is disturbing and requires further evaluation.

6. Public Water Supplies

Massachusetts has 213 active surface public water supplies. Water quality data indicate that 98-99% of these water supplies are in full compliance with standards for volatile organic compounds (VOC's) and nitrates based on analysis of data collected as part of a Compliance Source Water Protection Program. The state is taking an integrated approach to source water protection by improving state drinking water regulations, putting in place incentive programs for developing and implementing local protection measures as well as developing new technical assistance materials and workshops for public water suppliers.

Massachusetts currently has 2,562 groundwater public water supply sources. These and private wells serve over 45% of the population. Because Massachusetts is a relatively industrialized state these sources are at risk from anthropogenic sources. As of September 1993 contamination had caused permanent or temporary closure of 206 public water sources in 85 communities. All but two of these were groundwater supplies. Current monitoring data indicates 5.3% of these sources are threatened by VOC's and three sources have nitrate exceedences. Paralleling the surface supply protections the state also has a Comprehensive State Groundwater Protection Plan for improving regulations providing incentives and programs to provide higher levels of protection to water supply protection areas. Since 1986 222 approved recharge areas for 509 wells have been delineated for improved protection.

7. Wetlands Protection

There are over 588,000 acres of wetlands in Massachusetts today. Wetlands occupy 20-25% of the land area in southeastern Massachusetts, 10 - 20% of the land area in Northeastern and central Massachusetts and about 5% of the land area in western Massachusetts. About 2.4% of the wetland acres in Massachusetts consist of former cranberry bogs.

It is estimated that Massachusetts may have lost 28% of its total wetland area since colonial times. Along with this loss is the loss of wetland benefits such as wildlife habitat, flood protection and pollutant removal. The plan for protecting wetlands include a larger scale mapping of wetlands, biological documentation of coastal wetlands, and wetland restoration and banking programs. Coupled with substantial changes in wetland regulations these programs will be used to protect these resource areas rather than a formal statewide water quality monitoring and assessment program.

8. Groundwater

The state has established the following regulations for groundwater:

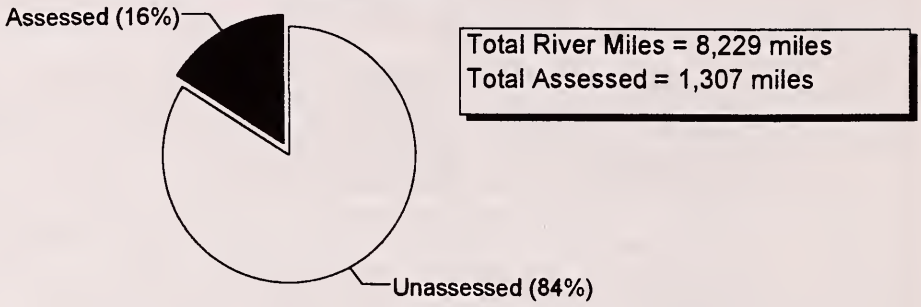
- Ground Water Discharge Permit Program (314 CMR 5.00)
- Ground Water Quality Standards (314 CMR 6.00)

The majority of groundwater discharge permits issued to date are for sanitary sewage discharged to the ground from small privately owned sewage treatment facilities the total discharge flow rate is approximately 15 million gallons per day. In addition to these facilities 650,000 individual subsurface sewage disposal systems (septic tanks) serving approximately 30 percent of the population operate in the Commonwealth. Impacts to drinking water supplies have been documented in densely populated areas which rely on septic systems prompting revisions to Title 5 of The State Environmental Code (310 CMR 15.00) to address this issue. The Ocean Sanctuaries Act has prohibited the introduction of new or increased wastewater discharges into designated Ocean Sanctuaries. This prohibition has resulted in several communities evaluating new or increased groundwater discharges.

Groundwater withdrawals are also a concern. During 1990 groundwater withdrawals totaled 329 million gallons a day and accounted for 24 percent of the total water withdrawals in Massachusetts. Over half of these withdrawals (54%) are for public water supply. Industrial, commercial and domestic withdraws make up the remainder. The Charles River Basin had the largest amount of groundwater withdrawals followed by Cape Cod.

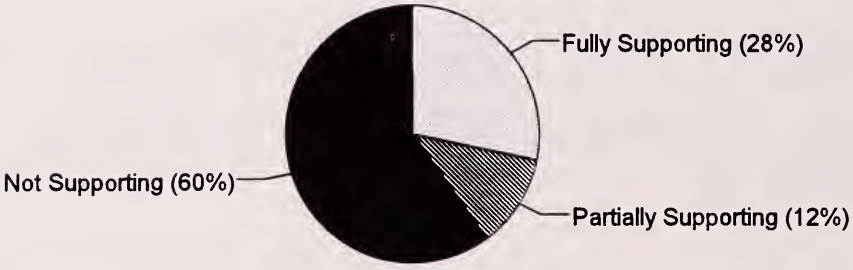
Figure 1
River Assessment

River Miles Assessed



Level of Overall Use Support

(Percent Assessed River Miles)



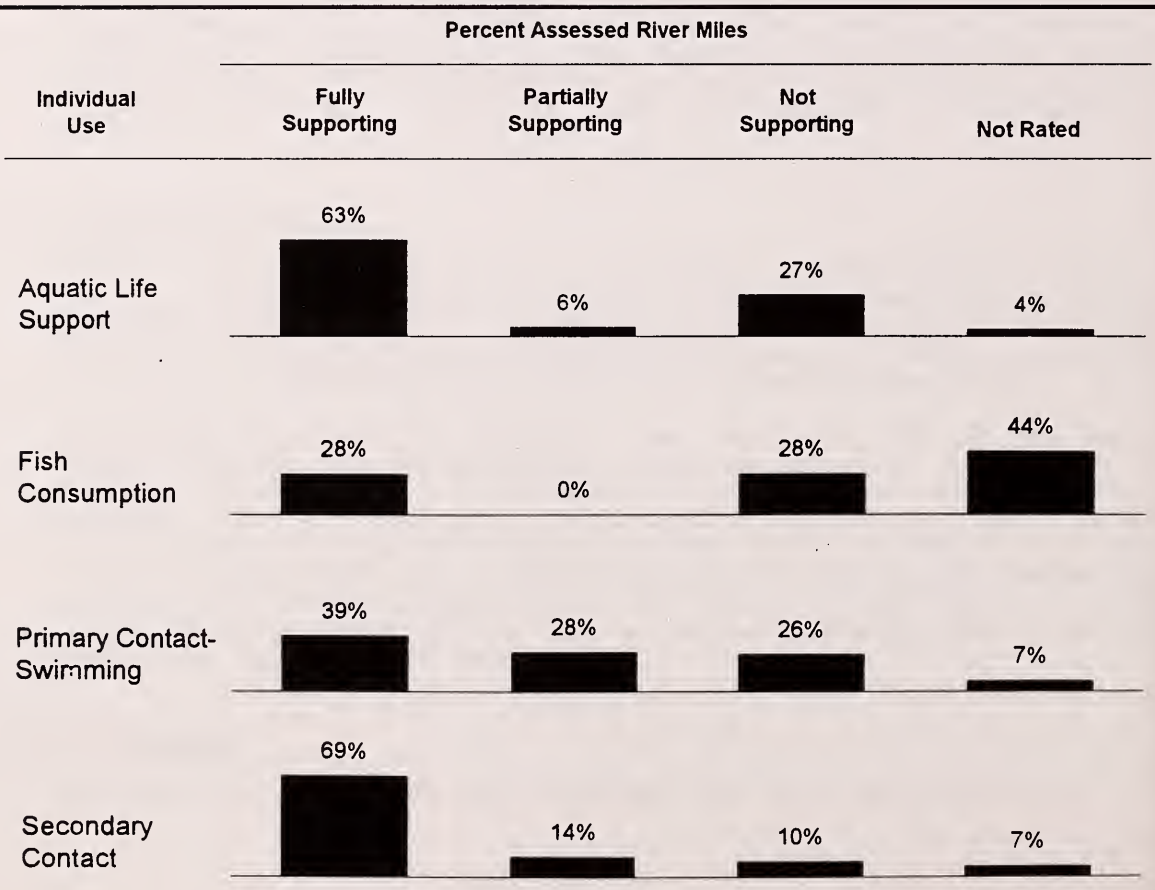
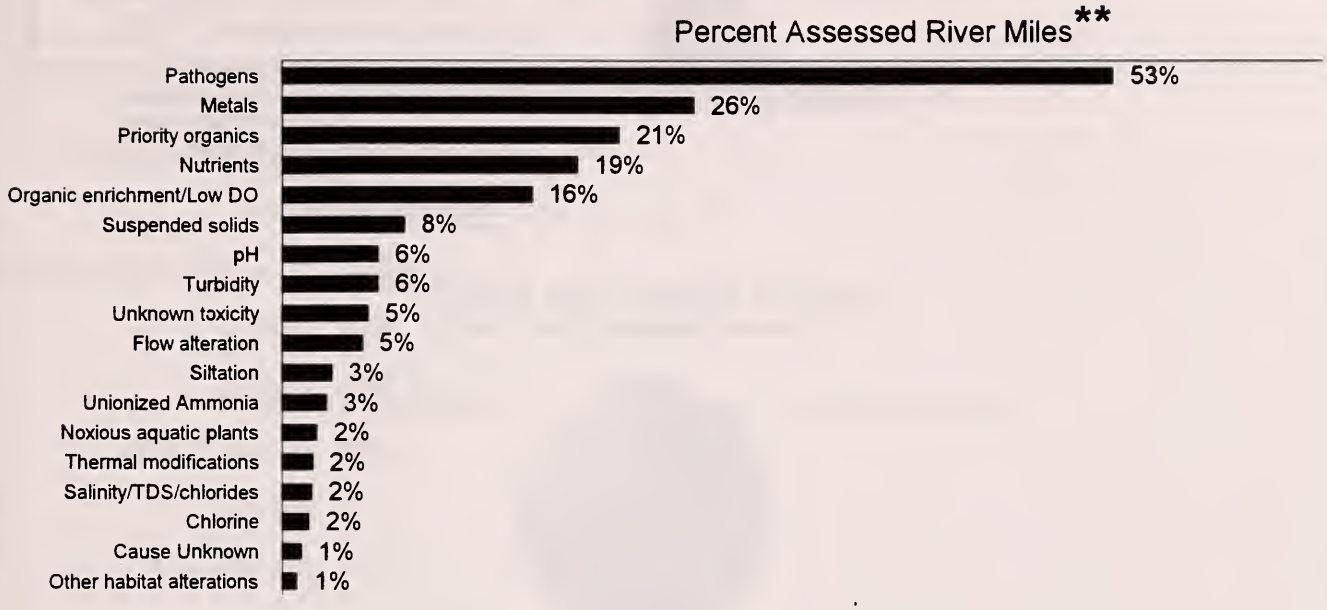
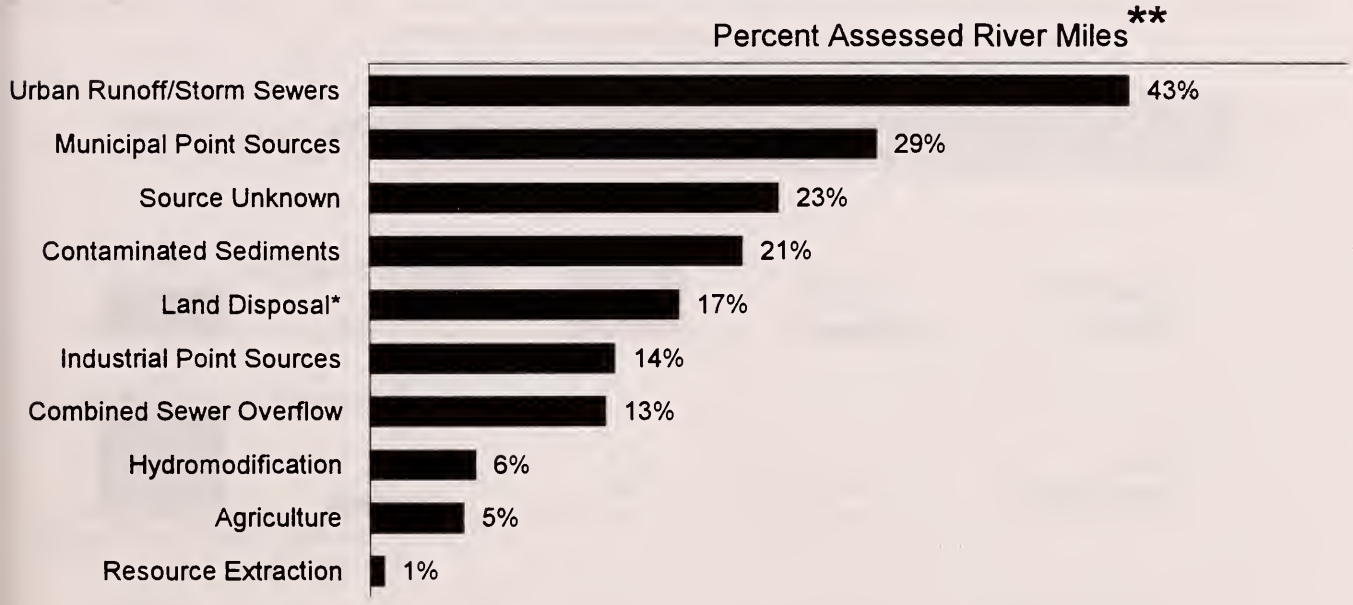


Figure 2
River Assessment

Pollutants/Causes of Impairment



Sources of Impairment

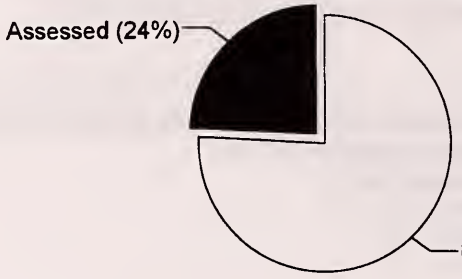


*-Includes onsite wastewater systems

** -River Miles Assessed = 1,307 miles

Figure 3
Lake Assessment*

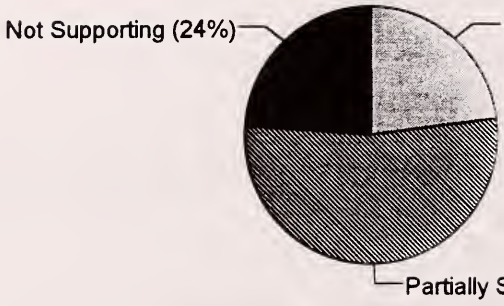
Lake Acres Assessed



Total Lake Acres = 126,173 acres
Lake Acres Assessed = 30,452

* - Does not include Quabbin Reservoir (25,000 acres) See text in section 4.2.1 for explanation

Level of Overall Use Support
(Percent Assessed Lake Acres)

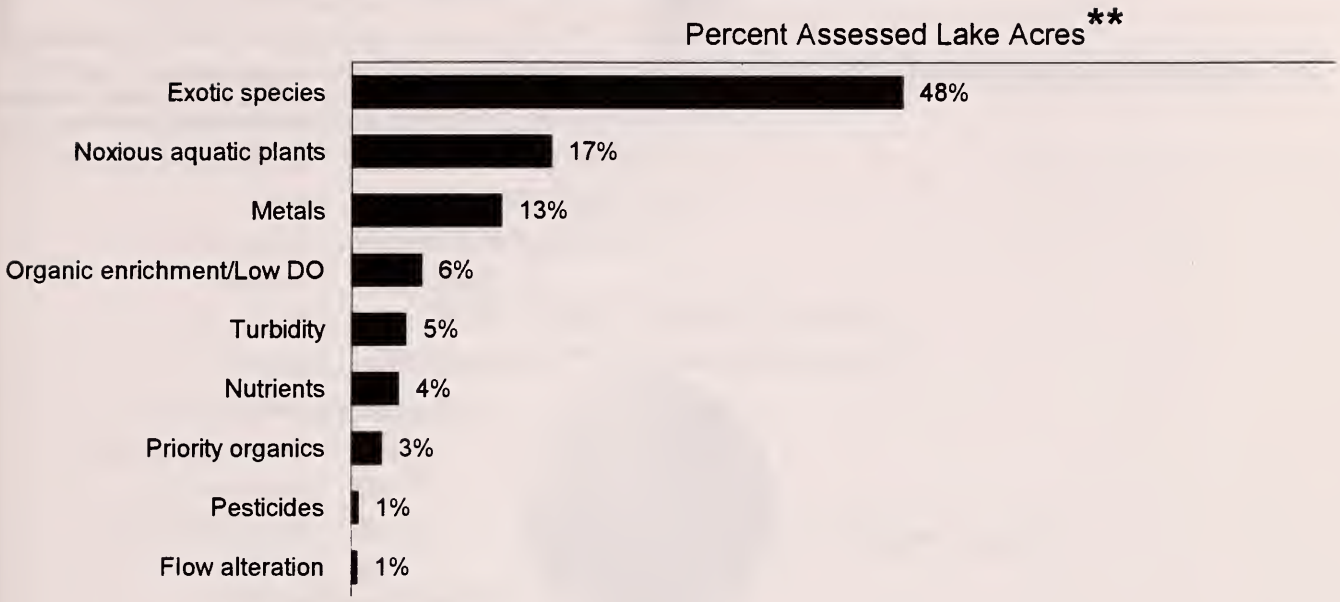


Percent Assessed Lake Acres

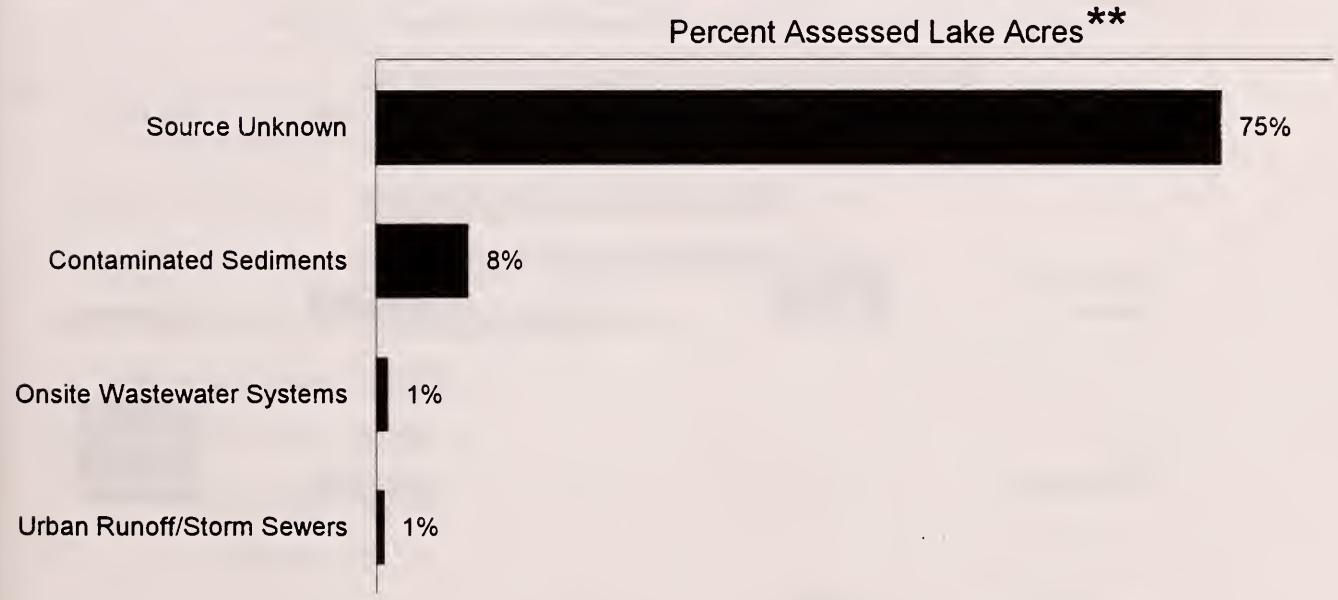
Individual Use	Fully Supporting	Partially Supporting	Not Supporting	Not Rated
Aquatic Life Support	9%	51%	2%	37%
Fish Consumption	1%	0%	15%	83%
Primary Contact-Swimming	27%	18%	8%	47%
Secondary Contact	59%	11%	7%	22%

Figure 4
Lake Assessment*

Pollutants/Causes of Impairment



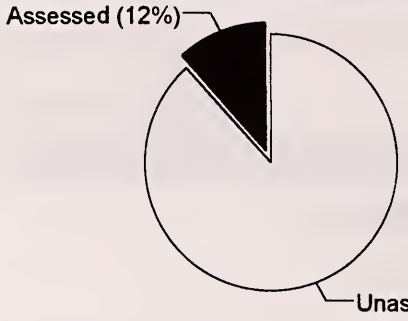
Sources of Impairment



*-Does not include Quabbin Reservoir
**-Lake Acres Assessed = 30,452 acres

Figure 5
Marine Waters Assessment

* Marine Waters Assessed, sq miles

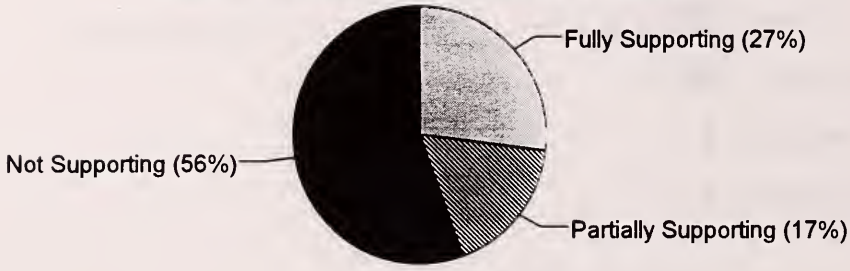


Total Marine Waters = 2,727 sq miles
Total Assessed = 218 sq miles

* - Relative comparison based on estimate of total marine waters using Division of Marine Fisheries shellfish management areas (see text for explaination)

Level of Overall Use Support

(Percent Assessed Marine Waters, sq miles)

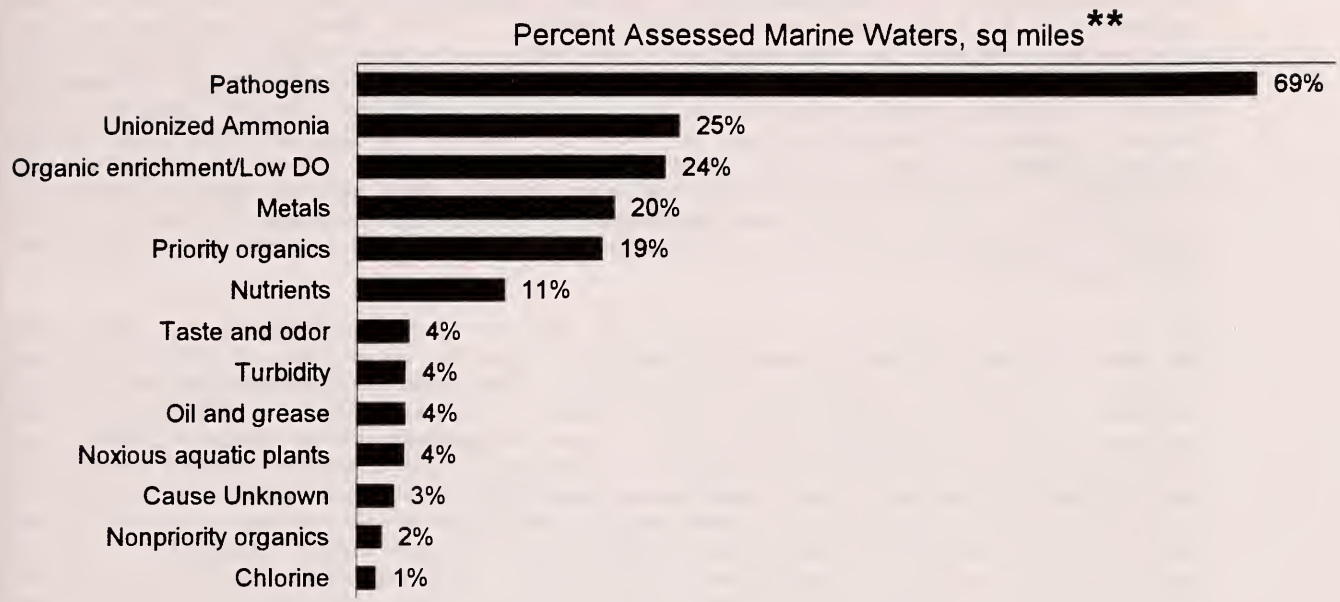


Percent Assessed Marine Waters, sq miles

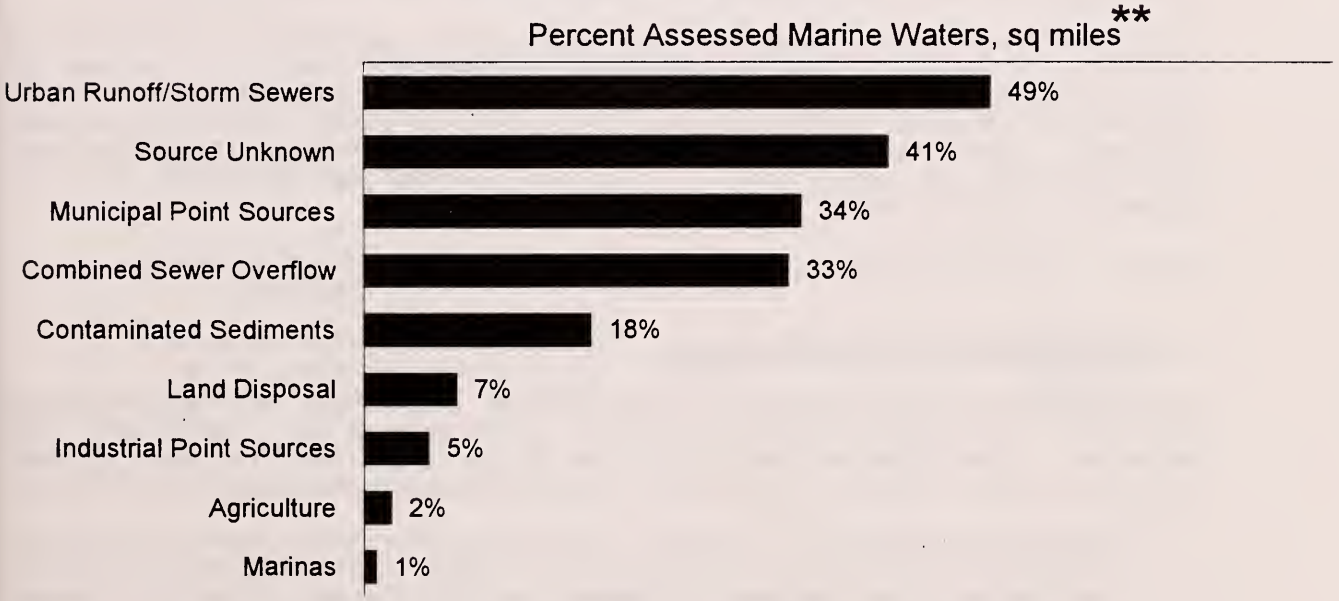
Individual Use	Fully Supporting	Partially Supporting	Not Supporting	Not Rated
Aquatic Life Support	50%	11%	29%	10%
Fish Consumption	0%	0%	21%	79%
Primary Contact-Swimming	46%	41%	7%	6%
Secondary Contact	85%	5%	5%	6%

Figure 6
Marine Waters Assessment

Pollutants/Causes of Impairment



Sources of Impairment



** -Marine Waters Assessed = 218 sq miles

2.0 BACKGROUND INFORMATION

2.1 Water Resources[1]

The Commonwealth of Massachusetts has the largest population of the six New England States with over six million people. More than 75 percent of the population resides in the eastern one-third of the state. Precipitation averages about 45 inches per year and is fairly evenly distributed through the state. Average annual evaporation of free water surfaces ranges from about 26 inches in Western Massachusetts to about 28 inches in the eastern half of the State. Yearly runoff ranges from about 20 inches in Cape Cod to about 32 inches in the northwestern corner of the State. The lowest runoff generally occurs during July, August and September. Runoff is highest in March in the eastern sections of the state and highest in April in the western sections and at higher elevations.

The geology of the state is divided into two provinces: the Coastal Plain and the New England Upland. Cape Cod and the Islands form the coastal plain and consist of low hills and plains covering unconsolidated sediments which form the most productive aquifers in the State. The New England Upland province consists of till and stratified drift above metamorphic and igneous rocks, and provides small productive aquifers. Groundwater is used for water supply in small communities and almost exclusively on Cape Cod and the Islands. Surface water is the major source of water supply for all the major urban areas in the state, since no other source is capable of meeting these demands. Surface water in the state is relatively plentiful, and of high quality, but not distributed in proportion to the distribution of the population. Two thirds of the people in the State depend upon surface water for their needs. The Metropolitan District Commission supplies communities in the Greater Boston area (about half the state usage of surface water) from reservoirs in the Chicopee and Nashua River basins.

Offstream water use is estimated at 2,500 million gallons per day (MGD) of freshwater withdrawals from surface and groundwater. Nearly 85 percent of this is surface water. Of these surface waters 71 percent is industrial self-supplied withdrawals (1,500 MGD) and 29 percent is public supply withdrawals (610 MGD). Agricultural uses (irrigation and livestock supply) comprise less than 1 percent of this total. In-stream use for hydroelectric power is estimated at 25,000 MGD.

Table 2.1 provides general water resources information for the State.

2.2 Water Pollution Control Program

The Department of Environmental Protection is responsible for administering the State's regulatory programs for the protection of air, water and land resources. The organizational structure of the Department is based on four priority areas: Resource Protection, Waste Prevention and Waste Site Cleanup.

(1) Resource Protection: Oversees and coordinates water resource programs including: the Watershed Management Program, the Water Supply Program, the Wetlands and Waterways Program, the Groundwater Protection Program and other water related and special projects. It also administers a program for training and certifying wastewater treatment plant operators, training and certifying septic system inspectors and soil evaluators. In 1996, the Bureau of Municipal Facilities was merged with

[1] Source: Gadoury and Wandle (1986).

TABLE 2.1

SURFACE WATER ATLAS

General[1]	
State Population (1990)	6,125,435
State Surface Area (Land) square miles	7,824
State Surface Area (Water) square miles	460
Rivers[2]	
Major Drainage Systems	9
Number of Sub-Basins	32
Interstate Sub-Basins	12
Total River Miles*	8,228.8
Number of Named Streams (subset)*	2,002
Miles of Named Streams (subset)*	5,460
Lakes	
Number of Lakes and Ponds[6]	3,191
Area of Lakes and Ponds (acres)[3]	151,173
Coastal Waters[4]	
Area of Harbors and Estuaries (square miles)	223.08
Total Coastal Miles	1,519
Wetlands[5]	
Total Area of Wetlands (acres)	588,486
Marine and Estuarine Wetlands (acres)	118,000
Freshwater Wetlands (acres)	470,486

Sources:

[1] Miser 1992
[2] Halliwell, et. al., 1982 and River Miles 1993
[3] Ackerman, 1989
[4] Gil, 1985 and Maietta, 1984
[5] Tiner, 1989
[6] Mass GIS 1:100,000 (DLG) by USGS

TABLE 2.2

WATERSHED PROTECTION

SCHEDULE

		FIVE YEAR CYCLE*				
	WATERSHED	**1997**	**1998**	**1999**	**2000**	**2001**
1.	Hudson Hoosic Kinderhook Bashbish	2	3	4	5	1
2.	Housatonic	2	3	4	5	1
3.	Deerfield	4	5	1	2	3
4.	Westfield	3	4	5	1	2
5.	Farmington	3	4	5	1	2
6.	Connecticut	1	2	3	4	5
7.	Millers	4	5	1	2	3
8.	Chicopee	1	2	3	4	5
9.	Quinebaug	5	1	2	3	4
10.	French	5	1	2	3	4
11.	Nashua	1	2	3	4	5
12.	Blackstone	1	2	3	4	5
13.	Merrimack	5	1	2	3	4
14.	Concord Assabet Concord Sudbury	3	4	5	1	2
15.	Shawsheen	4	5	1	2	3
16.	Parker	5	1	2	3	4
17.	Ipswich	4	5	1	2	3
18.	North Coastal	2	3	4	5	1
19.	Boston Harbor Mystic Neponset Weymouth & Weir	5	1	2	3	4
20.	Charles	2	3	4	5	1

TABLE 2.2 (Continued)

WATERSHED PROTECTION

SCHEDULE

		FIVE YEAR CYCLE*				
	WATERSHED	**1997**	**1998**	**1999**	**2000**	**2001**
21.	South Coastal North and South Rivers South Coastal Shore	3	4	5	1	2
22.	Cape Cod	5	1	2	3	4
23.	Islands	4	5	1	2	3
24.	Buzzards Bay	4	5	1	2	3
25.	Taunton	3	4	5	1	2
26.	Narragansett Bay and Mt. Hope Bay Shore	5	1	2	3	4
27.	Ten Mile	2	3	4	5	1

* **Year 1 - Outreach and Reconnaissance**
Year 2 - Information/Data Development
Year 3 - Water Resource Assessment
Year 4 - Planning and Implementation (includes permitting)
Year 5 - Implementation and Evaluation

the Bureau of Resource Protection and now operates as the Division of Municipal Services.

(2) Waste Prevention: Oversees and coordinates the Hazardous Waste Program, the Solid Waste Management Program, and the Air Quality Control Program.

(3) Waste Site Cleanup: Oversees and coordinates cleanups under State and Federal Laws, and any similar cleanup activities. Regional offices have teams that respond to chemical and hazardous waste spills and accidents.

(4) Municipal Services: Oversees the planning, design, construction and financing of municipal wastewater treatment facilities and sewer system projects. It also provides some funding for nonpoint source projects. Its regulations are being revised to link up to $200 million of loan capacity annually to watershed permittees.

2.3 The Watershed Protection Approach

A comprehensive water resource protection agenda is set forth in the "Clean Water Strategy" developed by the Department of Environmental Protection (DEP). The centerpiece of this strategy is a watershed approach to resource management. To this end, the watershed has been designated as the fundamental planning unit upon which integrated water quality management activities will be based. To implement the strategy, the DEP is reshaping its monitoring, permitting, compliance, enforcement, and public outreach programs.

In 1993, the DEP took the initial steps toward implementation of the Clean Water Strategy by synchronizing four functions according to a watershed-oriented regimen that had previously been performed in isolation. These are: water quality monitoring and assessment, water withdrawal permitting, nonpoint source pollution control, and wastewater permitting under the National Pollutant Discharge Elimination System (NPDES). Furthermore, this watershed-based assessment and permitting strategy provided the basis for the establishment of a new Division of Watershed Management within the DEP to bring the above-mentioned programs, and other water related programs, together into one organizational unit. By coordinating these programs, and focusing their activities in a particular watershed, the relationship between water quality and water quantity, and point and nonpoint source pollution will be better understood and more effectively communicated to the public.

A phased program for watershed-based assessment, permitting, and nonpoint pollution control has been adopted. The state was divided into 27 river basins (watersheds) and placed on a 5-year rotating schedule for implementation (Table 2.2). The annual objectives for each phase are:

Year 1 - Outreach and Reconnaissance - existing information and data are compiled. Input from outside agencies and the general public is actively solicited in order to gain further insight into water quality goals and to build partnerships with "stake-holders" who will play an increasingly important role in protecting these waters as the focus of water pollution abatement continues to shift to nonpoint source control measures.

Proposals for grants authorized by Section 604(b) of the Federal Clean Water Act are prepared. These grants which are available to regional planning agencies, government councils, conservation districts, and other planning agencies, are focused on watershed or subwatershed-based nonpoint source assessment type projects that provide diagnostic information in support of the basin-wide water quality management activities.

Year 2 - Information/Data Development - monitoring, which may include water column chemistry, sediment chemistry, toxicity testing, biocommunity assessment, habitat and flow measurements is conducted. Other sources of information identified in year one are reviewed. Findings are summarized for the stake-holders.

Year 3 - Water Resource Assessment - information from year two is used to assess existing water quality for the Section 305b report (statewide Summary of Water Quality). More detailed water quality/quality assessments may be conducted as warranted. Section 319 grant proposals are developed for the implementation of Best Management Practices (BMP's) or other control strategies for the control of nonpoint source pollution in priority waterbodies. Where necessary mathematical models are developed for determination of total maximum daily loads (TMDL's), load allocations and minimum flow requirements.
Year 4 - Planning and Implementation (including permitting) - activities are directed at developing and implementing various solutions to problems and threats of future problems. Permit and registration reviews are conducted. These may include the issuance of NPDES permits and the review of Water Management Act permits. A management plan (or mitigation plans) is prepared. Section 319 grant proposals are executed.

Year 5 - Implementation and Evaluation - the previous four years are reviewed and the information check list is updated. Preparations for the next five year cycle are made. Emphasis is placed upon any priority areas unaddressed in the previous cycle.

2.4 Surface Water Quality Standards

The Massachusetts Surface Water Quality Standards (314 CMR 4.00) define six water use classes for surface waters: A, B and C for inland waters and SA, SB and SC for coastal and marine waters. Each class designates multiple water uses for which the water quality shall be suitable. These uses are considered to be the most stringent or governing water uses. Waters may be suitable for other (unspecified) beneficial uses to the extent they are compatible with the designated uses. Table 2.3 summarizes the designated uses for each class.

Certain waters are designated for special protection under the antidegradation provisions of the Water Quality Standards. The antidegradation provisions restrict or prohibit the authorization of wastewater discharges to waters with critical resources. Most notable is the "Outstanding Resource Water" designation. This is a nondegradation designation that applies to all Class A waters and certain Class B, Class SA and Class SB waters. A comprehensive listing of Outstanding Resource Waters was published by the Department in July of 1993 and was updated in April of 1995. Inland waters are subcategorized as to fishery type (cold water fishery, warm water fishery and aquatic life) based on the waterbody's natural potential to support these uses. These subcategories determine the specific dissolved oxygen and temperature criteria to be applied.

The standards contain tables and maps that list and classify the more prominent waters of the state. Waters not specifically listed in these tables and maps are designated by the regulations as Class B for inland water and Class SA for coastal and marine waters. In addition, certain wetlands certified by the Department of Fisheries and Wildlife as vernal pools are designated for nondegradation (Outstanding Resource Waters).

All waters within the jurisdiction of the state are classified including, without limitation, rivers, streams, lakes, ponds, springs, impoundments, estuaries, wetlands, coastal waters and vernal pools. Separate regulations

TABLE 2.3

WATER USE CLASSES

WATER USE/CLASS	INLAND WATERS A	B	C	COASTAL & MARINE WATERS SA	SB	SC
1. Fish Consumption	x	x	x	x	x	x
2. Shellfishing	-	-	-	(x)	(x)[1]	-
3. Aquatic Life	x[2]	x[2]	x	x	x	x
4. Primary Contact Recreation	x	x	-	x	x	-
5. Secondary Contact Recreation	x	x	x	x	x	x
6. Aesthetics	x	x	x	x	x	x
7. Public Water Supply	x	-	-	-	-	-
8. Nondegradation	x	(x)	-	(x)	(x)	-
9. Agricultural Supply	-	x	x	-	-	-
10. Industrial Supply	-	x	x	-	-	x
11. Treated Public Supply	-	(x)	-	-	-	-

x - designated use
(x) - in specifically designated segments

[1] - Restricted Shellfish Areas
[2] - Subclasses for cold water, warm water fisheries and aquatic life

(314 CMR 6.00) classify groundwater. The water quality standards were most recently revised on March 1, 1995. The purpose of this revision was to clarify the relationship between the antidegradation provisions and the 401 Water Quality Certification implementation regulations for the discharge of dredged and fill material. The revisions clarifies that wetlands adjacent to Outstanding Resource Waters are also Outstanding Resource Waters. It further clarifies the specific restrictions of the discharge of dredged and fill material to these waters by coordinating with and cross-referencing the newly revised 401 regulations (314 CMR 9.00).

2.5 Point Source Programs

Wastewater Discharge Permitting - All wastewater discharges to surface waters in Massachusetts are governed by permits which are issued jointly by the United States Environmental Protection Agency (USEPA) and the Massachusetts Department of Environmental Protection in accordance with guidelines set forth as part of the National Pollutant Discharge Elimination System (NPDES). This system establishes levels of effluent quality that must be achieved at municipal and industrial treatment facilities to ensure that water quality standards are met in the receiving waters. Because Massachusetts has not been delegated the authority to issue these permits, USEPA permit writers draft them and submit them to the DEP for review and state certification. This process results in a final discharge permit which is valid under both Federal and State law, and as such, each permitting agency has the independent right to enforce its terms and conditions. The Clean Water Act (CWA) requires that discharges satisfy both minimum technology and water quality requirements.

The Department's Regulatory Program undertakes enforcement actions against violators of the Department's regulations or those in non-compliance with discharge permit requirements. Actions that the Department can initiate include: notices of non-compliance; administrative orders; administrative penalties; show cause hearings; and case referrals to the State's Attorney General's Office for action. These regulatory activities will continue to be a vital component of the Department's programs to ensure proper operation of municipal and industrial treatment facilities.

During the 1970's the Massachusetts Division of Water Pollution Control published river basin plans for over twenty river basins and coastal drainage areas in accordance with the requirements of Section 303(e) of the 1972 Federal Water Pollution Control Act (PL92-500). As part of this planning process, low-flow steady-state simulation models were developed for those basins where wasteload allocations were needed for the derivation of NPDES permit limits. While these models focused primarily on predicted impacts from conventional pollutants such as biochemical oxygen demand, they provided the basis for permit limits and treatment technologies at municipal and selected industrial facilities that are still in place today.

The 1980's saw an increased emphasis on the identification and control of toxic pollutants in the aquatic environment. During this time EPA announced the publication of 65 individual ambient water quality criteria documents for pollutants listed as toxic under Section 304(a) of the CWA. These and subsequent criteria documents were used by the DEP to screen ambient water quality data and wastewater discharge data to provide water toxics information to the EPA in 1989 in accordance with the requirements of Section 304(l) of the CWA. Specifically, waterbodies impacted by toxic pollutants and wastewater discharges in need of "individual control strategies" for toxic pollutants were identified and prioritized for implementation. Most of these control strategies involved the issuance of NPDES permits with whole-effluent toxicity testing

requirements and, in some cases, individual numerical effluent limits for toxic contaminants.

In 1990 DEP formally adopted the Section 304(a) criteria as part of its Surface Water Quality Standards, giving them direct regulatory impact. Also that year DEP adopted a "Toxics" Policy that set minimum requirements for whole effluent toxicity testing for NPDES permits. This has resulted in a substantial toxicity data base statewide.

Water Withdrawal Permitting - the Massachusetts Water Management Act (WMA), enacted in 1985, regulates all withdrawals from ground and surface water sources which exceed an average annual volume of 100,000 gallons per day. The WMA allowed all withdrawals of this magnitude that existed between 1981 and 1985 to be registered. New withdrawals sought after 1985 and exceeding the threshold volume were required to apply for a withdrawal permit. The application review process is being carried out watershed by watershed throughout Massachusetts. This process includes an analysis of the potential local impacts that may result from the proposed withdrawal. Included in this local impact analysis is the identification of resources affected by water level fluctuations and a determination of acceptable groundwater levels for those resources. The impact of water withdrawals on surface water quantity and quality, as well as the affects of induced infiltration on the quality of the withdrawal water are considered as a part of the review.

Municipal Services Planning/Funding - The Department's Division of Municipal Services has been a principal avenue through which substantial restoration of the Commonwealth's surface waters has been accomplished. Since its inception in 1966 (and its financial strengthening by the Federal Amendments to the Clean Waters Act (CWA) of 1972), the Municipal Facilities Program has provided over $3.5 billion for the construction of new or upgraded wastewater treatment facilities and construction or replacement of sewer system components (pump stations, force main sewers, etc.).

Although the financial expenditure has been substantial and has resulted in significant water quality improvements, there remains over $7 billion in unfunded wastewater needs and the ultimate success of the program will require continued expenditure of significant funds over the next decade and beyond.

The Municipal Services Program develops an annual priority list for construction projects based on a ranking system which is presented at public hearings. Much of the current funding is being expended on the Boston Harbor, South Essex Sewerage District and New Bedford projects. The demand for funds far outstrips their availability, thus creating a backlog of eligible projects and extending the time for abatement programs to be completed. The source and availability of funding is in a state of flux. The majority of the $3.5 billion in funds expended over the past twenty years were federal EPA and state monies provided in the form of grants. Under the provisions of the 1987 Federal Clean Water Act the Congress voted to replace the Federal/State EPA Construction Grant Program with a new State Revolving Loan Program (SRF). The Act authorized funds to be allocated to states through annual capitalization grants through Federal Fiscal Year 1994 however, Congress has continued to appropriate funds annually while re-authorization of the CWA is under consideration. These funds, when used with the mandatory 20 percent state match, are then made available as one-half market rate loans to municipalities to help finance critical water pollution abatement projects. Through FY-95, Federal capitalization grants totaling $417 million dollars have been awarded to the Commonwealth. The FY 1996 Federal budget includes additional monies for the SRF in anticipation of a continuation of authorization in the pending re-authorization of the Clean Water Act. With over $7 billion in unfunded wastewater needs identified in Massachusetts, it is

essential that the re-authorization of the Clean Water Act continues the SRF program on a long term basis.

Local sources of funding to repay the loans and to finance the non-fundable projects are being increased through higher user fees and other financial arrangements. The shift in funding mechanisms will increase the individual contribution from citizens. The Commonwealth Sewer Rate Relief Fund was established in Section 20 of the outside sections of the FY94 appropriation act (Chapter 110 of the Acts of 1993). The purpose was to mitigate the impact of sewer rate increases due to rising debt service. Section 20 appropriated $30,000,000, for this purpose. An additional $40 million was appropriated in each FY95 and FY96 and $47 million is proposed for FY97. Administration of the program was assigned to the Division of Local Services of the Department of Revenue in consultation with the Department of Environmental Protection through this Bureau. As part of this process, the Bureau reviews all Community requests for relief to determine if the debt service is for an eligible project.

The Department will place great emphasis on replacing and upgrading treatment facilities across the Commonwealth to ensure that the environmental benefits gained over the past two decades are not lost. This attitude will allow for the maintenance of a viable infrastructure for sewer systems and treatment facilities across the state. This approach is directly in line with the Department's strong commitment to the preservation of environmental resources.

2.6 Nonpoint Source Program

Nonpoint source pollution results from the flow of rainfall or snow melt over and through the ground and the subsequent transport of contaminants from natural and anthropogenic sources into surface or groundwater. Atmospheric deposition, in-place sediments, and hydrological modifications are also sources of nonpoint pollution. In the past, EPA and the states have focused water pollution abatement programs on the control of point sources through waste load allocation and NPDES permitting. Nonpoint source pollution is not as easily assessed nor controlled, for it is intricately linked with the use of the land, and land-use decisions are made at the local level. For this reason, Federal and State efforts are aimed at educating local officials and the public at large with respect to the importance of land-use planning and zoning, the use of best management practices (BMP) to control stormwater, and other measures for preventing nonpoint pollution. Critical to the success of this approach is the establishment of partnerships between all of the parties that have an interest in the process. By bringing these parties together, problems are identified and prioritized, and innovative solutions are developed. Moreover, the watershed represents a logical planning unit in which to focus this effort.

Unfortunately, impacts from nonpoint sources and the effectiveness of control measures are not easily determined, and monitoring and assessment methodologies are required that differ from those traditionally employed. Whereas the worst effects of point sources are typically exhibited at critical low-flow receiving stream conditions associated with summer-time dry weather, effects of nonpoint pollution are linked to the occurrence of storms and other climatic factors such as snow melt. The magnitude and frequency of rainfall and the degree to which natural runoff patterns have been altered through changes in land use all play a major role in determining the quality of receiving waters.

While the relationship between land use and water quality in the watershed is generally recognized, scientifically valid approaches to identifying and quantifying nonpoint pollution sources, and predicting the results of proposed control measures on downstream water quality are not well developed. Nonetheless, several watershed-scale models have been developed in recent years

which can be used as screening tools for predicting nonpoint pollution loading from storm events based on a knowledge of land use characteristics. These screening procedures require little input data or calibration and verification, and consequently, output is not highly accurate. Nonetheless, they can be used to make relative comparisons between subwatersheds and to highlight areas for more intensive data gathering and modeling efforts. It is anticipated that the control of nonpoint pollution will be an iterative process whereby the implementation of BMPs will be followed by monitoring to measure their effectiveness, and to identify needs for further loading reductions.

The Nonpoint Source Management Plan was originally developed by the DEP in 1988 pursuant to Section 319 of the CWA. This plan, which is undergoing revision at the present time, sets forth an integrated strategy for the prevention, control, and reduction of pollution from nonpoint sources in an effort to protect and improve the quality of the waters of the Commonwealth. Each year the Congress appropriates funds under Section 319 to assist the states with the implementation of their approved Nonpoint Source Management Plans. Implementation activities include regulatory enforcement, technical assistance, education, training, technology transfer, and demonstration projects. Only those implementation strategies identified in the Management Plan are eligible for federal funding.

As stated above, the state Nonpoint Source Management Plan is implemented on a prioritized watershed basis. This pertains to the core Nonpoint Source Program funded under Section 319 of the CWA. Not all of the ancillary state programs that address nonpoint source pollution are similarly focused. Nevertheless, the DEP will promote the use of a watershed approach by other state agencies and public entities in the implementation of the Nonpoint Source Management Plan.

DEP is currently in the process of revising its SRF regulations to provide municipalities with financial assistance for the correction of nonpoint source pollution consistent with the Nonpoint Source Management Plan. It is anticipated that up to $2.5 million could be available for nonpoint source projects in FY'96.

The enactment by Congress of the 1990 amendments to the Coastal Zone Act (CZARA) has significant implications for the Massachusetts Nonpoint Management Plan. Section 6217 of CZARA includes the requirements and specifications for the development of state coastal nonpoint source management plans in accordance with program guidance from NOAA and technical guidance from EPA. The technical guidance contains requirements, or management measures, for nonpoint source controls which state programs must ensure will be implemented in an enforceable manner. The coastal management plans must assess the enforceability and effectiveness of existing programs for controlling nonpoint source pollution, and propose changes to correct gaps in legislative or regulatory authorities for addressing nonpoint source pollution. In Massachusetts, the DEP and the Office of Coastal Zone Management (CZM) have agreed that the coastal nonpoint pollution control program will be an integral part of the comprehensive state Nonpoint Source Management Plan. The provisions of the coastal plan will thus be implemented statewide to maintain consistency of purpose and applicability of nonpoint source management strategies. This agreement has been formalized in a Memorandum of Understanding which establishes a working relationship between the two agencies, and clarifies their roles with regard to the development and implementation of the Coastal Nonpoint Pollution Control Plan. Massachusetts's Coastal Nonpoint Source Program is one of only a handful of states nationwide that has received conditional approval.

On the horizon, the Department of Environmental Protection and the Office of Coastal Zone Management are collaborating on a Stormwater Management Policy. In addition to existing control mechanism guidance, the policy will provide

performance - based standards and the tools necessary to undertake a stormwater control program. The policy, directed at Conservation Commissions, Planning Boards and developers, was issued in November 1996 followed by publication of a two-volume handbook in March, 1997. Also, in August 1996 the Rivers Protection Act passed the state legislature. This new law creates protected riverfront areas which extend 200 feet on both sides of rivers and streams and impose restrictions on any development within those areas. In densely populated areas, the riverfront area is reduced to 25 feet. Developers will have to show that their proposed projects would have no adverse impacts on the riverfront areas, and that there is no practicable alternative for development. The enactment of this law and the issuance of the stormwater policy are anticipated to be major milestones in curbing nonpoint source pollution. Regulations promulgated under the Rivers Act will take effect on October 1997.

2.7 Cost/Benefit Assessment

It is difficult to report on the economic and social costs and benefits of actions necessary to achieve the objective of the Clean Water Act. Until such time as procedures become available it is possible to discuss the capital investments in municipal facilities and provide information on the beneficial outcomes of these actions.

Massachusetts Cost

Capital investments in public water pollution control facilities have been estimated to be about $4B over the period 1968 to 1993 in Massachusetts; this spans the "era" of construction grants which were transformed into loans during the early 1990s. the $4B investment consisted of federal state and local funding. Through the federal and state shares changed but their sum remained constant at 90% of eligible costs. The long term average is estimated to be 65% federal funding and 25% state funding. Because the figure of $4B is a rough approximation, attempting to distinguish between eligible and total capital costs is not fruitful. Another factor that would affect total expenditures is the fact that while the federal portions came from operating funds, state and local funds came nearly exclusively from bond issues; thus the true cost would have to take into account the interest on the bonds. Even for the federal funds, some apportioning of the debt cost because of deficit spending during the time of the grants program would have to be assigned. However, unless and until solid figures are established, these refinements are not justified.

In addition to capital costs, operating costs also must be counted. This is difficult information to reconstruct but at least for the early 1990s, one can use the estimates based on Census Bureau surveys. The latest available figures for Massachusetts are from 1990-1. The figure for total expenditures is approximately $715M; of this, $437M was capital outlay, leaving $278M as non-capital expenditures which are assumed to be operating costs.

This path leads to an estimated total expenditures for POTW construction of $6.8B for the 20 year period 1972-1992. This figure is consistent with the expectation that it would be larger than the informed estimate provided by the program people. Given the qualitative consistency and many caveats used to derive the figure of $6.8B, it makes sense to use the $4B estimate as the working figure unless more refined estimates are made in the future.

Massachusetts Benefits

Documentation of the water quality benefits from the large expenditure of funds on controlling point sources is limited. Partly in response to this, Isaac (1991) presented information demonstrating improvement in dissolved oxygen at

several sites in Massachusetts. While statistically significant, these improvements were documented at fixed stations on different rivers and therefore did not provide estimates on the spatial extent (i.e., river miles) of such improvements. In the 1990 Summary of Water Quality (305b report), Massachusetts made some estimates of improvements in water quality between 1979 and 1989. The miles monitored were 1523 in 1979 and 1623 in 1989. Most of the 1523 miles in 1979 were included in 1989's 1623 miles. For five of the six parameters POTWs are designed to or can control (ammonia, nutrients, dissolved oxygen (and therefore biochemical oxygen demand--BOD), pathogen indicators, and suspended solids, improvements were noted. Chlorine, which actually is added for disinfection, was the exception to this trend of improvement. The information is summarized in Table 2.4.

Since different areas are affected by more than one constituent, one can not infer from these data what percentage of waters do not meet standards. Given that many nonpoint and minor sources can contribute to indicator bacteria, a better variable for judging the impact of POTWs (and private ones as well) is dissolved oxygen. The percentage of river miles monitored meeting the dissolved oxygen criterion increased from approximately 60% in 1979 to nearly 75% in 1989.

It should be noted that major progress had been made between the late 1960s and 1979. The four locations at which continuous monitoring of dissolved oxygen showed statistically significant improvement occurred in the mid-1970s (Isaac, 1991).

For dissolved oxygen suspended solids and bacteria associated with municipal discharges, perhaps the best way of estimating the river miles improved is to review (or reconstruct) the mathematical water quality models that were used to determine the waste load allocations. The expected minimum improvement would be the miles predicted not to be meeting water quality standards for DO under the conditions existing at the time the model was developed. To this could be added the river miles between the point of discharge and the point of DO going below the standard to account for suspended and other solids. Bacteria would be considered only for those discharges that were receiving no treatment at all in the late 1960s (e.g., Adams on the Hoosic), in cases where treatment was being provided, disinfection was practiced.

As recently as the 1960s, many coastal discharges received minimal (e.g., screening) if any treatment before discharge. These discharges included those from Gloucester, Lynn, Boston Metropolitan Area served by the north (Deer Island) outfall, Taunton, and New Bedford. The water quality improvements achieved by providing at least primary treatment, and soon secondary, for all of these discharges are difficult to quantify because the ability to monitor waters (other than shellfish areas) has been very limited. For marine waters between 1979 and 1989, not much had changed in terms of actual treatment provided; most facilities were in the planning stage or only recently completed. For those in the second category, assessments of water quality improvements had not been done. However, because monitoring that was done focused on problem areas, it is reasonable to assume that all of the waters monitored did improve in quality while not necessarily meeting all water quality standards because of other sources such as runoff and/or combined sewer overflows. The 1990 305b reports 136 square miles of marine waters assessed; therefore, it is reasonable to use this figure as the number of square miles in which water quality improved through the expenditures of funds for POTWs.

Because lakes in Massachusetts are affected nearly entirely by nonpoint sources and only minor amounts of funding relative to that for point sources has been expended on controlling these sources, it is not appropriate to consider lake water quality in the context of POTW funding. Therefore, an analysis for lakes merits a separate effort.

TABLE 2.4

CAUSES OF IMPAIRMENT 1979 - 1989

(PERCENT OF MONITORED RIVER MILES)

CONSTITUENT	1979 (1523 River Miles Monitored)	1989 (1623 River Miles Monitored)
Ammonia	18.0	2.0
Nutrients	40.9	23.8
Chlorine	<0.1	0.9
Dissolved Oxygen	39.7	23.8
Pathogen Indicators	65.3	54.2
Suspended Solids	17.0	2.5

A rough measure of the cost of improving water quality to date can be obtained by assuming of the river miles assessed plus as all of the marine waters assessed (even though square miles are being added to miles) can act as the denominator. Thus, for at the current time using 1623 river miles plus 136 square miles for marine waters provides a value for the denominator of 1759 (which will be referred to as miles). Using $4.0B as the total funds spent on POTWs in Massachusetts since the late 1960s yields a cost of approximately $2 M/mile for improved water quality. To place this figure in perspective, the cost for construction a super highway is estimated to be about $1 M/mile.

3.0 SURFACE WATER MONITORING AND ASSESSMENT METHODS

3.1 Surface Water Monitoring Program

Surface water monitoring and assessment activities of the Department's Bureau of Resource Protection are performed by personnel of the Division of Watershed Management (DWM), (formerly the Office of Watershed Management) established in 1993 to provide the institutional framework for watershed-oriented resource assessment and water quality management. The goals of the monitoring program are to support the following programs:

1. NPDES wastewater discharge permit program - establishing permit limits and compliance;

2. Water Management Act (WMA) permit program - establishing permit limits and compliance;

3. the nonpoint source pollution control program - characterizing and ranking existing and emerging problems to target implementation strategies; and the 305b water quality assessment program;

4. assessing the status and trends in water quality.

These goals have resulted in a highly targeted monitoring program, in which much of the monitoring was conducted at sites of known or suspected poor water quality. These areas tend to be of most interest to the public and/or in most need of management attention. For this reason the information represents only the individual sites and cannot be extrapolated beyond the sites actually monitored.

DWM's monitoring program focuses on the ecological condition of the waterbody; primarily the uses of aquatic life protection, primary contact recreation and secondary contact recreation. Information regarding human health related issues is collected and/or interpreted by other agencies; drinking water (Division of Water Supply), shellfishing (Division of Marine Fisheries) and fish consumption (Dept. of Public Health with DWM data). The basic monitoring elements of the DWM program are listed in Table 3.1. A list of surveys performed during 1994 and 1995 is presented in Table 3.2.

3.2 River Water Quality Monitoring

A rotating basin planning approach has been adopted whereby river monitoring activities are conducted in each river basin at five-year intervals. Historically, river surveys were typically performed during low-flow, dry-weather conditions which generally represented the worst-case scenario with respect to the assessment of impacts of receiving water quality from point discharges. Today, increased attention is focused on the identification and control of nonpoint pollution and survey methods are changing to reflect this shift in emphasis. For example, wet-weather sampling may provide the most reliable information pertaining to nonpoint pollutant loading from stormwater runoff, and, when compared with dry-weather survey data, may further distinguish the effects of point and nonpoint pollution sources. In addition, biomonitoring techniques, which integrate instream conditions over time, represent a sound alternative to wet-weather chemical sampling when evaluating nonpoint sources of pollution, particularly in those watersheds where point discharges do not occur.

TABLE 3.1

BASIC MONITORING ELEMENTS

Category	Indicator
Physical	Flow
	Temperature
	Suspended Solids
	Turbidity
	Transparency[1]
	Substrate Characterization
Chemical	Dissolved Oxygen
	pH
	Conductivity
	Chlorides[2]
	Salinity[3]
	Hardness[1,2]
	Total Kjeldahl Nitrogen
	Nitrate Nitrogen
	Ammonia Nitrogen
	Total Phosphorus
	Metals[4]
	Toxics in Sediments[4]
Biological	Fecal Coliform Bacteria
	Chlorophyll a[1]
	Phytoplankton[1]
	Macrophyton[1]
	Benthic Invertebrates[2]
	Fish Population
	Fish Flesh Toxics[4]
	- Metals
	- Organics (PCB)
	- Pesticides (dioxin)
	Habitat Assessment

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[1] Lakes, ponds and impoundments only
[2] River and streams only
[3] Marine waters only
[4] In specifically targeted areas only

TABLE 3.2

SURFACE WATER SURVEYS

1994 - 1995

BASIN	WATERBODY	SURVEY ELEMENTS[1] WATER QUALITY	RBP[2]	BIOACCUMULATION[3]
Blackstone	Flint Pond	-	-	+
Buzzards Bay	Glen Charlie Pond	-	-	+
	Snipatuit Pond	-	-	+
	Buttonwood Brook	+	-	-
Cape Cod	Mashpee-Wakeby Pond	-	-	+
	Lake Wequaquet	-	-	+
	Great Pond	-	-	+
Charles	Charles River	-	-	+
Concord	Lake Cochituate	-	-	+
	Concord River	-	+	-
Deerfield	Sherman Reservoir	-	-	+
	Deerfield River	++	+	-
	North River	+	+	-
	Bear River	+	+	-
	South River	+	+	-
	Green River	+	+	-
	Pelham Brook	+	-	-
	Cold River	+	-	-
	Chickley River	+	-	-
	Bozrah Brook	+	-	-
	Mill Brook	+	-	-
	Clesson Brook	+	-	-
	Clark Brook	+	-	-
	Bog Pond	+	-	+
	Ashfield Pond	+	-	+
	Plainfield Pond	+	-	+
French	French River	-	+	-
	Town Meadow Brook	-	+	-
	Clara Barton Pond	-	-	+
Housatonic	Ashley Lake	+	-	+
Ipswich	Ipswich River	+	+	+
	Martins Brook	+	+	-
	Howlett Brook	+	+	-
	Fish Brook	+	+	-
	Martins Pond	-	-	+
	Lubbers Brook	+	-	-
	Bear Meadow Brook	+	-	-
	Wills Brook	+	-	-
	Norris Brook	+	-	-
	Miles River	+	-	-

TABLE 3.2 (Continued)

SURFACE WATER SURVEYS

1994 - 1995

BASIN	WATERBODY	SURVEY ELEMENTS[1] WATER QUALITY	RBP[2]	BIOACCUMULATIO
Ipswich (Cont.)	Labor in Vain Creek	+	-	-
	Black Brook	+	-	-
	Gravelly Brook	+	-	-
	Boston Brook	+	-	-
	Maple Meadow/Mill Brook	+	-	-
	Kimball Brook	+	-	-
Islands	Long Cove Pond	-	-	+
	Seths Pond	-	-	+
	Upper Lagoon Pond	-	-	+
	Gibbs Pond	-	-	+
	Long Pond	-	-	+
	Miacomet Pond	-	-	+
Merrimack	Merrimack River	++	+	+
	Beaver Brook	+	+	-
	Spicket River	+	+	-
Millers	Otter River	+	+	-
	Tully River	-	+	-
	Lawrence Brook	-	+	-
	Lake Dennison	-	-	+
	Lake Rohunta	-	-	+
	Upper Naukeag Lake	+	-	+
	Hilchey Pond	+	-	+
	Sheomet Lake	+	-	+
	Upper Reservoir	+	-	+
	Laurel Lake	+	-	+
	Gales Pond	+	-	+
Mount Hope Bay	Cook Pond	-	-	+
	North Watuppa Pond	+	-	+
Mystic	Clay Pit Pond	-	-	+
Nashua	Mirror Lake	-	-	+
	Fitchburg Reservoir	+	-	+
	Lake Wampanoag	+	-	+
Neponset	Neponset River	+	+	+
	Mine Brook	+	-	-
	Mill Brook	-	+	-
	Spring Brook	+	-	-
	Hawes Brook	+	+	-
	Germany Brook	+	-	-
	Meadow Brook	+	-	-
	Traphole Brook	+	+	-

TABLE 3.2 (Continued)

SURFACE WATER SURVEYS

1994 - 1995

BASIN	WATERBODY	SURVEY ELEMENTS[1] WATER QUALITY	RBP[2]	BIOACCUMULATION[3]
Neponset (Cont.)	Massapoag Brook	+	+	-
	Beaver Brook	+	-	-
	Pequid Brook	+	-	-
	Beaver Meadow Brook	+	-	-
	Purgatory Brook	+	-	-
	Pecunit Brook	+	-	-
	Ponkapoag Brook	+	-	-
	Mother Brook	+	-	-
	Pine Tree Brook	+	+	-
	Gulliver Creek	+	-	-
	Unquity Brook	+	-	-
	Willet Pond	-	-	+
Parker	Parker River	+	+	-
	Wheeler Brook	+	-	-
	Jackman Brook	+	+	-
	Penn Brook	+	-	-
	Beaver Brook	+	-	-
	Mill River	+	+	-
	Great Swamp Brook	+	-	-
	Bachelder Brook	+	-	-
	Ox Pasture Brook	+	+	-
	Little River	+	-	-
	Pentucket Pond	-	-	+
Quinebaug	Quinebaug River	-	+	-
	Cady Brook	-	+	-
	Hamilton Reservoir	-	-	+
Shawsheen	Shawsheen River	++	+	-
	Ballardvale Impoundment	-	-	+
	Elm Brook	+	-	-
	Vine Brook	+	-	-
	Strong Water Brook	+	-	-
	Rogers Brook	+	-	-
South Coastal	Indian Head River	-	-	+
	Forge Pond	-	-	+
Taunton	Lake Mirimichi	-	-	+
	Elders Pond	+	-	+
	West Meadow Pond	+	-	+
	Little Quitticas Pond	+	-	+
	Somerset Reservoir	+	-	+
	Middle Pond	+	-	+
	Watson Pond	+	-	+
	Prospect Hill Pond	+	-	+

TABLE 3.2 (Continued)

SURFACE WATER SURVEYS

1994 - 1995

BASIN	WATERBODY	SURVEY ELEMENTS[1] WATER QUALITY	RBP[2]	BIOACCUMULATI
Westfield	Center Pond	+	-	+
	Crooked Pond	+	-	+
	Yokum Pond	+	-	+
	Buckley-Dunton Lake	+	-	+
Weymouth/Weir	Lake Holbrook	-	-	+

Notes [1] Elements included in the survey are denoted by +
[2] Rapid Bioassessment Protocols
[3] Fish or invertebrate tissue assays

River stations are located at dams, below wastewater discharges, at tributaries, and in impoundments. These locations are chosen to assess the water quality and effects of pollution sources and natural changes. Surveys are conducted periodically to update old data, and to examine conditions before and after a major upgrading of a treatment plant, the addition of a new discharge, or the implementation of Best Management Practices (BMPs) for controlling nonpoint sources of pollution.

River surveys are sometimes supplemented by wastewater discharge sampling which serves to document pollutant loading from point sources to the river at the time of the survey, and to assess compliance with NPDES discharge permit limits. Once sampling is completed and data are received from the laboratory, results are presented and discussed in technical memoranda or published reports. Results of compliance sampling, coupled with the review of discharge monitoring reports submitted by the permittees, enable Department personnel to prioritize facilities for technical assistance, enforcement action, or permit modification.

3.3 Lake Monitoring

The Department's Lake Water Quality Monitoring Program was formally initiated in the summer of 1974 and was significantly expanded in its scope during most of the 1980s. The focus of monitoring has changed over time and lake monitoring has been incorporated into the watershed approach. Lake monitoring will now be conducted in the context of a review of issues within each basin. While overall lake monitoring will be less than at the peak of the program, the monitoring conducted will be in the highest priority areas.

During the years, limnological sampling was conducted to: a) determine baseline lake conditions, b) monitor post-implementation projects, and c) respond to public concerns about lake problems. From 1994 until now sampling has been to biological surveys of the macrophyton communities and limited "in-situ" measurements using metered probes. Baseline surveys by the Department are occasionally scheduled under special request. The Department of Environmental Management has been conducting baseline surveys on lakes associated with state parks since the early 1990s.

A baseline survey is generally conducted in one day and consists of bathymetric mapping of the lake; physical, chemical and biological sampling of the open water areas, tributary stream(s), and outlet; and a quantitative and qualitative mapping of the aquatic macrophyton community in the lake. The primary purpose of this survey is to estimate lake trophic status and identify any point and nonpoint sources of pollution. The lake is sampled during the summer months when productivity is high.

The "synoptic" surveys now being conducted have two primary goals. First, they provide information necessary to make a minimum assessment of lake quality biennially for this report. Second, they are used to document the spread of several non-native and potentially nuisance aquatic plant species that are known to be present in the Commonwealth.

3.4 Coastal Monitoring

In addition to river and lake monitoring, coastal watershed studies often contain a marine (estuarine) component, conducted primarily by boat. On-board meters (deployed from a 22-foot boat) are used to obtain "in situ" measurements of chlorophyll, dissolved oxygen, temperature, salinity, conductivity, and density. These data can be supplemented with analyses of phytoplankton community structure. A major issue that is addressed with this

approach is the potential for impacts due to nutrient enrichment (plankton blooms, shifts in phytoplankton community structure, low dissolved oxygen) such as might result from effluents of wastewater treatment facilities. Instead of measuring nutrients directly, the integrators of nutrient enrichment, i.e., phytoplankton standing crop (or possibly productivity), dissolved oxygen concentrations and percent saturation of dissolved oxygen, and to some extent the phytoplankton community structure, are analyzed. The oceanographic conditions that can exacerbate the affects of nutrient enrichment, such as depth of light penetration and occurrence of stratification (by measuring profiles of salinity, density and temperature within the water column) are also measured.

3.5 Biomonitoring

Biomonitoring is an integral component of the watershed-based water quality management program. Its importance is underscored in the "Declaration of Goals and Policy" Section 191 (a) of Public Law 92-500 (1972) which stresses the need to restore the biological integrity of the nation's waters and achieve a water quality which provides for the protection and propagation of aquatic life.

Biomonitoring activities encompass four areas of emphasis: macroinvertebrate rapid assessment, bioaccumulation, toxicity testing, and microbiology. The Department's biologists perform habitat assessments and conduct biological sampling to supplement other water quality monitoring and management programs and make recommendations with regard to the control of toxic effluents and thermal discharges through the NPDES permitting process. A Biomonitoring Program Standard Operating Procedures (SOP) manual documents all field and laboratory methods used while carrying out the various program elements. This manual is updated periodically. More detailed information on each biomonitoring element is presented below.

Assessment of Benthic Macroinvertebrate Communities

Rapid bioassessment protocols (RBPs) are used to monitor the health of benthic macroinvertebrate communities as indicators of pollution impacts. These methods were developed to minimize laboratory time requirements for taxonomic identification and enumeration of benthos. Kick-net samples are collected at sites for upstream/downstream comparisons, comparisons against a regional or surrogate reference, or for long-term trend monitoring at fixed sites. Two different levels of analysis are employed, RBP II or RBP III (Plafkin, et al. 1989), depending on the objectives to be served.

A 100-organism subsample is extracted from the original kick sample in the field (RBP II) or the laboratory (RBP III). Specimens are identified to family (RBP II) or to genus or species level (RBP III); the taxonomic data are then compiled to rank water quality on the basis of a series of metrics including:

1) Taxa richness;
2) modified Family Biotic Index (RBP II), or modified Hilsenhoff Biotic Index (RBP III);
3) functional feeding groups (scrapers/filtering collectors);
4) ratio of the number of EPT individuals to the number of chironomidae individuals;
5) percent contribution by the dominant taxon;
6) EPT index;
7) percent similarity of community structure.

Based on scoring of these metrics three categories of impairment are discerned by the RBP II (nonimpaired, moderately impaired, and severely impaired), while the RBP III distinguishes between four (nonimpaired, slightly impaired, moderately impaired, severely impaired).

The RBPs are conducted at up to 25 sampling sites per year in conjunction with comprehensive water quality surveys. Results are used to supplement traditional physicochemical analyses by demonstrating actual instream impacts of pollutants, as well as assessing ambient water quality and habitat conditions throughout a particular watershed.

Bioaccumulation Assessment

Bioaccumulation assessment comprises the Toxics-in-Fish Monitoring Program aimed primarily at the assessment of human health risk associated with the consumption of potentially contaminated freshwater fish, and special studies whereby invertebrate organisms such as caddisflies or crayfish are assayed for the presence of toxic contaminants as a measure of environmental pollution effects.

The Fish Toxics Monitoring and Assessment Program is a cooperative effort between four Department offices/divisions (i.e., Watershed Management, Research and Standards, Water Pollution Control, and Environmental Analysis) and the Department of Fisheries, Wildlife, and Environmental Law Enforcement, and the Department of Public Health. Fish tissue monitoring is conducted to assess the levels of toxic contaminants in freshwater fish, identify waterbodies where those levels may impact human health, and identify waters where toxic chemicals may impact fish and other aquatic life. Fish surveys generally have been restricted to waterbodies where wastewater discharge data or previous water quality studies have indicated potential toxic problems. For example, sampling has been performed in areas of industrial and commercial development, or known or suspected hazardous waste disposal sites. Furthermore, in recent years, an attempt has been made to sample up to five waterbodies each year at the request of private citizens. Because of limited resources, human health concerns have received higher priority in the surveys carried out thus far. Therefore, fish tissue analysis has been restricted to edible fish fillets.

Uniform protocols, designed to assure accuracy and prevent cross-contamination of samples, are followed for fish collection, processing and shipping. Fish are taken with electroshocking gear or gill nets. Lengths and weights are measured, and fish are visually examined for tumors, lesions, or other indications of disease. Scale samples or other hard parts (e.g., pectoral spines) are obtained from each sample to determine the approximate age of the fish.

Once at the laboratory, samples may be analyzed for specific toxicants (where a particular source is suspected) or for a broad spectrum of heavy metals, pesticides, or organic chemicals. Laboratory analysis includes chromatography/mass spectrometry.

The use of tissue bioassays to trace the movement of toxic contaminants in the aquatic environment has been explored on a limited basis, as time and resources permit. Caddisfly and crayfish bioassays have been used to identify possible sources of PCB's in the Hoosic River Basin. In coastal waters work has focused on both heavy metals and organic chemicals (e.g., PCB's, PAH) in blue mussels, and heavy metals in seaweeds such as the brown alga, Fucus sp.

Toxicity Testing

In-house toxicity testing capabilities do not exist in the Department at the present time. However, some ambient water column and sediment toxicity tests are performed, as needed to support river basin monitoring activities, in cooperation with the U.S. EPA New England Regional Laboratory in Lexington, MA. This laboratory conducts standard acute and chronic toxicity tests using both freshwater and marine test organisms, according to U.S. EPA approved methods. In addition, effluent toxicity testing is required as a condition of all major NPDES wastewater permits in force in Massachusetts. Toxicity data are used to assess the impacts of point and nonpoint sources of toxic contamination in surface waters throughout Massachusetts and to formulate recommendations for abating toxic pollution through the NPDES permitting process, Toxicity Identification and Reduction Evaluations (TIE/TRE), and other water quality management strategies.

Microbiology Program

Microbiological monitoring includes both the maintenance of a small support laboratory for algal identifications and chlorophyll determinations, and the assessment of bacterial indicators of water pollution. The algal counts and chlorophyll results are measures of primary production and are used to evaluate the trophic status of lakes, ponds, and impoundments. Data from riverine and coastal waters are used to identify those waterbodies subjected to nutrient enrichment and consequent algal and macrophyte growth. Algal indicators of the presence of elevated metals concentrations, nutrient enrichment, or other pollutants are noted.

3.6 Ecoregions and Biocriteria

The Department with the help of consultants, plans to conduct a pilot study for the development of numeric biocriteria based on ecological subregions. The study will seek to identify and sample least-"disturbed" (or minimally impacted) reference sites in wadable rivers. Sites will coincide with defined subregions based on bedrock, soils, potential natural vegetation, landform and, where it is an overriding factor, land use. A composite of reference stations within an subregion should account for the full range of variability to be expected for the biological communities sampled. These will serve as the benchmark for evaluating other sites in the same subregion and as a valid basis of establishing numeric biocriteria. Properly developed biocriteria can become incorporated in the Water Quality Standards and become an important regulatory tool to augment physical and chemical criteria.

3.7 Data Sources for Assessments

The Department draws from an extensive data base in order to assess the waters of the Commonwealth. During the past 30 years the Division of Watershed Management (and its predecessor agency) has collected water quality information at over 3,000 locations in the state and published 609 technical reports on this information. The coverage of these reports, by river basin, is summarized in Table 3.3. In addition the Division has conducted over 100 separate biological studies of macroinvertebrates, fish, bacteria and other aquatic communities.

TABLE 3.3

PUBLICATIONS OF THE DIVISION OF WATERSHED MANAGEMENT 1962 - 1995

Summary of Report Types

BASIN/DRAINAGE AREA	PERIOD OF RECORD[1]	REPORT CATEGORY A	AB	ABC	AC	B	BC	C	CD	D	E	TOTAL
Hudson Drainage System												
Hoosic River Basin (11)	1965-91	5	4	-	-	6	-	1	1	1	1	19
Housatonic Drainage System												
Housatonic River Basin (21)	1963-92	5	2	-	2	7	-	4	-	2	3	25
Connecticut Drainage System												
Farmington River Basin (31)	1974-89	1	-	-	1	-	-	-	1	-	1	4
Westfield River Basin (32)	1965-90	2	3	1	-	4	-	2	-	1	1	14
Deerfield River Basin (33)	1965-88	2	1	2	-	7	-	2	-	2	-	16
Connecticut River Basin (34)	1966-90	9	1	-	-	5	-	1	-	2	1	19
Millers River Basin (35)	1965-87	6	3	-	-	8	-	2	-	2	1	22
Chicopee River Basin (36)	1966-90	6	2	3	1	4	-	1	-	2	9	28
Thames Drainage System												
Quinebaug River Basin (41)	1968-89	1	1	2	-	-	-	-	-	1	1	6
French River Basin (42)	1975-87	-	-	1	-	-	-	-	-	-	1	2
(French and Quinebaug Basins (41/42))	1963-85	3	3	-	-	5	-	2	-	2	1	16
Narragansett Bay Drainage System												
Blackstone River Basin (51)	1962-89	7	3	-	-	8	-	2	-	2	5	27
Ten Mile River Basin (52)	1964-85	5	3	-	-	5	1	3	-	1	1	19
Mount Hope Bay Drainage System												
Mount Hope Bay (Shore) Drainage Area (61)	1970-75	1	1	-	-	-	-	-	-	-	1	3
Taunton River Basin (62)	1964-89	6	1	3	-	8	-	2	-	4	3	27
Boston Harbor Drainage System												
Mystic River Basin and Coastal Drainage Area (71)	1967-88	5	-	-	1	1	-	1	-	-	2	10
Charles River Basin and Coastal Drainage Area (72)	1967-90	8	2	2	2	7	-	3	-	2	4	30
Neponset River Basin and Coastal Drainage Area (73)	1973-86	2	-	1	-	2	-	1	-	-	-	6
Weymouth and Weir River Basins and Coastal Drainage Area (74)	1975-89	1	1	1	-	-	-	-	-	-	1	4
Boston Harbor Drainage System (7)	1969-88	1	6	1	-	5	-	-	-	-	1	14
Merrimack Drainage System												
Nashua River Basin (81)	1968-89	5	3	1	-	5	-	3	-	2	4	23
Concord River Basin (82)	1965-91	8	2	4	-	4	-	3	-	4	8	33
Shawsheen River Basin (83)	1968-89	2	-	-	1	-	-	-	1	-	-	4
Merrimack River Basin and Coastal Drainage Area (84)	1968-90	4	2	4	-	5	-	3	2	1	2	23
Coastal Drainage System												
Parker River Basin and Coastal Drainage Area (91)	1968-84	1	-	-	1	-	-	-	-	-	-	2
Ipswich River Basin and Coastal Drainage Area (92)	1968-90	2	1	1	1	-	-	-	-	1	-	6
(Parker and Ipswich Basins and Coastal Drainage Areas (91/92)	1976-81	1	-	-	-	2	-	-	1	-	1	5
North Shore Coastal Drainage Area (93)	1975-90	5	1	1	-	1	-	-	-	1	-	9
South Shore Coastal Drainage Area (94)	1968-89	2	4	-	1	3	-	2	-	3	1	16
Buzzards Bay Coastal Drainage Area (95)	1971-88	7	-	-	-	5	-	3	-	1	2	18
Cape Cod Coastal Drainage Area (96)	1976-83	-	1	-	-	1	-	1	-	1	3	7
Islands Coastal Drainage Area (97)	1975-88	1	1	-	1	1	-	-	-	1	-	5
Coastal Drainage System (9)	1992	-	-	-	-	1	-	-	-	-	-	1
	Totals	**114**	**52**	**28**	**12**	**110**	**1**	**42**	**6**	**39**	**59**	**463**

Miscellaneous Statewide Publications	**134**
Miscellaneous Regional Publications	**13**
TOTAL	**609**

[1] Denotes earliest and most recent survey year

The Department has also used information supplied by the following sources:

State Agencies

Division of Marine Fisheries
Division of Fisheries and Wildlife
Division of Water Supply
Division of Wetlands and Waterways

Federal Agencies

U.S. Geological Survey
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service

Private Consulting Firms

Various Facilities Plans
Massachusetts Clean Lakes Program 628 projects (70 lakes)
Service Contract for Toxicity Testing

Scientific Organizations

Woods Hole Oceanographic Institute
Water Resources Research Center
Massachusetts Institute for Social and Economic Research
Boston Harbor Symposium Abstracts

Other Sources

Various Conservation Commissions (nonpoint source assessment)
Municipal and Industrial NPDES Permit Monitoring Requirements

The assessment uses this information to make a judgment about the degree to which the designated uses of a waterbody are supported. In some cases it is appropriate to make judgments based on information other than monitoring data. This information includes land use patterns, location of sources of pollution, predictive modeling and citizen complaints. Assessments made on these types of information or on monitoring data more than five years old, are considered "evaluated waters". When the use support decision is based principally on current site-specific ambient data the waterbody is considered "monitored waters".

3.8 Individual Use Assessments

Each designated water use is assessed as to 1) support; 2) partial support; and 3) non-support. The term "threatened" is used to define a category of waters that fully support their designated uses but may not support those uses in the future because of adverse pollution trends or anticipated sources of pollution.

Section 101(a)(2) of the Federal Clean Water Act states that it is the national goal that wherever attainable water quality shall provide for the protection and propagation of fish, shellfish and wildlife and provide for recreation in and on the water. For the purpose of this report the national goal is reported as four separate uses:

1) fish consumption;
2) aquatic life protection;
3) primary contact recreation
4) secondary contact recreation

The use "Shellfishing" is used in this report to denote specifically regulated state commercial and recreational activities. These are considered above and beyond the national goal use of shellfish protection which is included in the use "aquatic life protection."

The use "Drinking Water" is used in this report for those waters specifically designated Class A public water supplies and Class B treated water supplies.

In monitored waters the assessment is made by comparing the data collected with criteria and guidelines developed for each particular use. Criteria are specified in the Surface Water Quality Standards. These regulations adopt EPA's criteria for toxic pollutants (section 304(a) of the Clean Water Act). When no specific criteria are available for a pollutant, guidance published pursuant to Section 304(a) of the Clean Water Act is used to determine acceptable concentrations. Tables 3.4 and 3.5 summarize both the rational and the criteria used to make assessments for aquatic life, primary contact recreation, secondary contact recreation and aesthetics. Assessments for fish consumption, drinking water and shellfishing are made using data bases and criteria from other agencies. Table 3.6 summarizes the guidelines for determining the degree of use support for each use.

Uses are assessed independently in the following manner:

1) Aquatic Life - Chemical data, from the water column and sediment, toxicity tests and biosurvey results are used to make this assessment. The nature, frequency and precision of the Department's data collection techniques dictate that a weight of evidence be used to make the assessment with biosurvey results used as the final arbiter of borderline cases. The use is supported when the data available clearly indicates support. Minor excursions from chemical criteria may be tolerated if the biosurvey results demonstrate support. The use is partially supported when there is uncertainty about support in the chemical or toxicity testing data; or there is some minor modification of the biological community. The use is not supported when there are frequent or severe violations of chemical criteria; or there is a severe adverse modification of the biological community.

2) Primary Contact Recreation - The use is supported when bacterial criteria are met and there are no overriding aesthetic considerations that preclude the use. The use is partially met when bacterial criteria are exceeded on an intermittent basis that is neither frequent or prolonged or there are marginal aesthetic violations. The use is not supported if there are frequent or prolonged violations of criteria, where there are formal bathing area closures or where there are severe overriding aesthetic considerations that preclude the use.

3) Secondary Contact Recreation - The use is supported if bacterial guidance is met and there are no overriding aesthetic considerations that preclude the use. The use is partially supported if bacterial guidance is exceeded on an intermittent basis that is neither frequent or prolonged or there are marginal aesthetic considerations that may preclude the use. The use is not supported when bacterial guidance is exceeded frequently or for prolonged periods or where severe aesthetic violations preclude the use.

TABLE 3.4
RATIONALE FOR WATER QUALITY CRITERIA

INDICATOR GROUP	AQUATIC LIFE	PRIMARY RECREATION	SECONDARY RECREATION
1. Dissolved Oxygen (BOD, benthic demand, redox potential).	Required for respiration of aquatic life. Affects toxicity.	Anaerobic water is unaesthetic.	Anaerobic water is unaesthetic.
2. pH (Ionic strength, hardness, alkalinity, conductivity, salinity, total dissolved solids.	Affects life, toxicity and chemical processes, alters habitat suitability.	Extreme pH irritates eyes.	
3. Temperature	Affects life processes and community structure.	Affects deep body temperature of swimmers.	
4. Nutrients (phosphorus, ammonia, nitrate).	Affects productivity, toxicity and community structure.	Affects macrophyton and plankton growth (eutrophication).	Affects macrophyton and plankton growth.
5. Toxic Pollutants (ammonia, chlorine, priority pollutants, toxicity tests).	Toxic to aquatic life.	Toxic to swimmers.	Acute toxicity to aquatic life is unaesthetic.
6. Sediment Chemistry (toxics, nutrients).	Toxic to aquatic life.	Toxic to humans, affects eutrophication.	
7. Tissue Chemistry (toxics).	Shows exposure, potential toxicity to aquatic life.		
8. Suspended Solids (turbidity, color, secchi disc depth).	Reduces habitat. light penetration, clogs gills, affects primary productivity can trap and transport toxics.	Affects safety and aesthetic enjoyment.	
9. Aesthetics (deposits, scum, oil & grease, taste & odor).		Unattractive to water users.	Unattractive to water users.
10. Flow	Depth and flow needed for habitat.		Maintenance of flow for rafting, migration of fish.
11. Substrate	Affects habitat, chemical availability.		

TABLE 3.4 (CONTINUED)
RATIONALE FOR WATER QUALITY CRITERIA

INDICATOR GROUP	AQUATIC LIFE	PRIMARY RECREATION	SECONDARY RECREATION
12. Bacteria		Potential pathogen exposure from ingestion.	Potential pathogen exposure from incidental contact
13. Macroinvertebrates	Assemblage reflects ecosystem health, structure and function.		
14. Fish	Assemblage reflects ecosystem, health structure and function.		
15. Macrophyton	Biomass indicates habitat, food and trophic status.	Rooted and floating plants can entangle bathers.	Dense growths impair boating and fishing.
16. Plankton/Periphyton	Biomass indicates primary production. Assemblage indicates trophic status, specific chemical effects, toxicity.	Biomass effects swimming, aesthetics.	Biomass effects boating, aesthetics.

TABLE 3.5
WATER QUALITY CRITERIA FOR ASSESSMENTS

INDICATOR GROUP	AQUATIC LIFE	PRIMARY RECREATION	SECONDARY RECREATION
1. Dissolved Oxygen	Cold Water SA ≥ 6.0 mg/l ≥ 75% Saturation Warm Water SB ≥ 5.0 mg/l ≥ 60% Saturation	AEROBIC ≥ 1.0 mg/l	
2. pH	Inland 6.5 - 9.0 Δ0.5 Coastal 6.5 - 8.5 Δ0.2	6.5 - 8.3	
3. Temperature	Inland Cold ≤ 68°F (20°C) Δ 3°F (1.7°C) Warm ≤ 83°F (28.3°C) Δ3°F (1.7°C) Lakes Δ5°F (2.8°C) Rivers Coastal ≤ 85°F (29.4°C) ≤ 80°F (26.7°C) Mean SA - Δ 1.5°F (0.8°C) SB - Δ 1.5°F (0.8°C) July-Sept. Δ 4.0°F (2.2°C) Oct.-June	59 - 86°F (15 - 30°C)	
4. Nutrients	Control Cultural Eutrophication (Site-Specific Criteria)		
5. Toxic Pollutants Ammonia-N Chlorine Other Toxicity Tests	Inland 0.5 mg/l* Coastal 0.25 mg/l* 0.011 mg/l TRC 0.0075 mg/l CPO CWA Section 304(a) Criteria ≤ 0.05 Toxic Units Ave. ≤ 0.3 Toxic Units Max.	Site-Specific Criteria	
6. Sediment Chemistry	Inland Ontario Guidelines for L-EL and S-EL Coastal NOAA Guidelines for ER-L and ER-M	Site-Specific Criteria	
7. Tissue Chemistry	Site-Specific Criteria		
8. Suspended Solids Turbidity Transparency	≤ 10.0 mg/l	Δ 5 N.T.U. ≥ 4.0 secchi disc depth	

TABLE 3.5 (CONTINUED)
WATER QUALITY CRITERIA FOR ASSESSMENTS

INDICATOR GROUP	AQUATIC LIFE	PRIMARY RECREATION	SECONDARY RECREATION
9. Aesthetics Oil & Grease		No Objectionable: 1. deposits 2. floating debris, scum other matter 3. color, odor, taste or turbidity 4. nuisance or undesirable species of aquatic life Free from visible sheen, oily taste in the water, objectionable deposits on banks or bottom.	
10. Flow	U.S. Fish and Wildlife Policy IFIM		Fish passage and rafting: B.P.J.
11. Substrate	RBP II and III Analysis		
12. Bacteria Fecal Coliform		< 5 samples ≤ 400/100 ml ≥ 5 samples ≤ 200/100 ml geometric mean ≤10% of samples ≥ 400/100 ml	< 5 samples ≤ 2000/100 ml ≥ 5 samples ≤ 1000/100 ml geometric mean ≤10% of samples ≥ 2000/100 ml
13. Macroinvertebrates	RBP II - non impaired RBP III - non impaired or slightly impaired		
14. Fish	BPJ		
15. Macrophyton	BPJ	BPJ Lakes - cover of macrophytes < 50% of lake area at maximum extent of growth.	
16. Plankton/Periphyton	BPJ	BPJ	

Δ = Change from ambient
* = Ammonia levels for pH of 8.3 and temperature 25°C
TRC - Total Residual Chlorine, CPO - Chlorine Produced Oxidants
BPJ - Best Professional Judgement
RBP - Rapid Bioassessment Protocol

TABLE 3.6

GUIDELINES FOR DETERMINING DEGREE OF USE SUPPORT

USE	SUPPORT	PARTIAL SUPPORT	NON-SUPPORT
1. Aquatic Life (MA Surface Water Quality Standards and Sediment Guidelines from NOAA and Ontario)	Criteria met or Minor excursions of chemical/toxicity data and biocommunity Healthy	Uncertainty (Data inconclusive or insufficient for full support ranking)	Criteria not met or Biocommunity modification
2. Primary Contact Recreation 3. Secondary Contact Recreation 4. Aesthetics (MA Surface Water Quality Standards)	Criteria met	Intermittent excursions from criteria that are neither frequent or prolonged	Frequent or prolonged excursions from criteria or formal bathing area closures
5. Fish Consumption (Advisories and Bans/ Dept. of Public Health)	No restrictions or bans	Restricted consumption advisory population	"No consumption" advisory for general population or sub-
6. Drinking Water (MA Drinking Water MCL's/Division of Water Supply)	Criteria met	One or more advisories issued or Greater than normal treatment needed	Violations of criteria or contamination - based closure
7. Shellfishing (Shellfish Closures/ Division of Marine Fisheries)	SA Waters Approved areas SB Waters Approved, conditionally approved, restricted areas	SA Waters Conditionally approved, conditionally restricted areas SB Waters Conditionally restricted areas	SA Waters Prohibited areas SB Waters Prohibited areas

( ) Source of criteria or decision guidelines.

4) Aesthetics - the aesthetic use is closely tied to the public health aspects of the recreational uses (swimming and boating). The use is supported when there are no objectionable bottom deposits, floating debris, scum, or nuisances; objectionable odor, color, taste or turbidity, or nuisance aquatic life. The use is partially met if one or more of these attributes is present but never for frequent or prolonged periods of time. The use is not met when one or more of these conditions is either frequent or prolonged.

5) Fish Consumption - This assessment is made using information from the Massachusetts Department of Environmental Health, Bureau of Environmental Health Assessment's Fish Consumption Advisories. The use is supported when their are no fish advisories or bans in effect. Waters partially support the use when a "restricted consumption" fish advisory is in effect for the general population or a sub-population that could be at potentially greater risk (e.g., pregnant women, children). Restricted consumption is defined as limits on the number of meals consumed per unit time for one or more fish species. The use is not supported when there is a "no consumption" advisory or ban in effect for the general population or a sub-population for one or more fish species; or there is a commercial fishing ban in effect.

6) Drinking Water - This use is assessed using information and criteria from the Department of Environmental Protection's Division of Water Supply. It is largely finished water data from public water supplies that draw from surface water supplies, along with use restriction information. The use is supported when there are no contaminants with confirmed exceedences of Maximum Contaminant Levels (MCL's), no closures or advisories, and conventional treatment is adequate to maintain the supply. The use is partially supported when there is one or more advisories or more than conventional treatment is required. The use is not supported when there is one or more contamination based closures of the supply.

7) Shellfishing - This use is assessed using information from the Department of Fisheries, Wildlife and Environmental Law Enforcement's Division of Marine Fisheries. The information is in the form of various classifications of shellfish closures and restrictions. The use is supported in Class SA waters where shellfish beds are classified as approved areas. The use is supported in Class SB waters for approved, conditionally approved and restricted areas. The use is partially supported in SA waters for conditionally approved and conditionally restricted areas. The use is partially supported in SB waters for conditionally restricted areas. The use is not supported in SA and SB waters for prohibited areas. "Management" closures are considered unassessed.

In addition to these uses, Outstanding Resource Waters (nondegradation waters), industrial supply and agricultural supply are designated in the water quality standards but not assessed in this report.

3.9 Overall Use Support

Each water use classification is designated for multiple uses. After individual uses are assessed the overall use support of a waterbody is assessed as follows:

Support: all uses are fully supported.

Partial Support: one or more uses are partially supported and the remaining uses are fully supported.

Non-Support: one or more uses are not supported.

3.10 Causes and Sources of Impairment

Impaired waters are those waters that are assessed as not fully supporting their designated uses (the combination of partial support and non-support assessments).

When impairment is assessed the assessment includes the "causes" of impairment. Causes are those pollutants and other stressors that contribute to the impairment of the designated uses. Stressors are factors or conditions (other than specific pollutants) that cause impairment (e.g. flow or other habitat alterations, exotic or nuisance species of aquatic life). Each cause is assigned a waterbody size (miles, acres, square miles) according to the extent of impairment from that cause. The causes used in this assessment are listed in Table 3.7.

Sources are the activities, facilities, or conditions that contribute pollutants or stressors resulting in impairment of designated uses. To the extent possible each assessment contains a list of the sources of impairment and the waterbody size that is affected by the source. A list of sources used in this report are in Table 3.8. Determining the sources of designated use impairment can be the most data intensive part of the assessment because it demands a causal relationship to be determined. Monitoring data and professional judgement are usually enough to determine obvious sources (major point sources, hydro-modification, nearby land use problems). However more subtle sources require sophisticated analysis techniques in order to make inferences, which may not be warranted by the level of data collection. Therefore the sources listed in the assessment are those that the assessor has confidence in linking with causes. Suspected sources or unconfirmed sources are listed as "unknown."

TABLE 3.7

CAUSES OF IMPAIRMENT

1. Cause Unknown
2. Unknown Toxicity
3. Pesticides
4. Priority Organics
5. Non Priority Organics
6. Metals
7. Ammonia (Un-ionized)
8. Chlorine
9. Other Organics
10. Nutrients
11. pH
12. Siltation
13. Organic Enrichment/Low Dissolved Oxygen
14. Salinity/Total Dissolved Solids/Sulfates
15. Thermal Modifications
16. Flow Alterations
17. Habitat Alterations (other than flow)
18. Pathogens
19. Radiation
20. Oil and Grease
21. Taste and Odor
22. Suspended Solids
23. Noxious Aquatic Plants
24. Turbidity
25. Exotic Species

TABLE 3.8

SOURCES OF IMPAIRMENT

1. Industrial Point Sources
2. Municipal Point Sources
3. Combined Sewer Overflow
4. Agriculture
5. Silviculture
6. Construction
7. Urban Runoff/Storm Sewers
8. Resource Extraction
9. Land Disposal
10. Hydro-modification
11. Habitat Modification (other than hydro-modification)
12. Marinas
13. Contaminated Sediments
14. Source Unknown

4.0 THE SURFACE WATER ASSESSMENT

4.1 River Assessment

DEP has maintained a fixed monitoring network for rivers over the last 25 years. The network covers approximately 20% of the total river miles in the State. It encompasses all known point sources of pollution, all major urban areas, and other areas where there are suspected sources of pollution. It includes each of the principal rivers in the State. It does not include many minor tributaries and small headwater streams with no known sources of pollution. From a point source perspective these smaller streams could be evaluated as supporting their uses. However, the contribution of nonpoint source pollution is unknown and therefore these numerous tributaries remain assessed.

The rivers that are included in the monitoring network generally did not support their uses 25 years ago, many of these rivers were grossly polluted. Therefore, the assessments in this report monitor the progress of pollution abatement activities on these major rivers.

4.1.1 Overall Use Support

A total of 1306.75 river miles were assessed in 227 river segments for 1996.

Full support was assessed for 368.5 river miles (28% of the total assessed). Partially supporting was assessed for 154.45 river miles (12% of the total assessed). Not supporting was assessed for 783.80 river miles (60% of the total assessed).

There is a temptation to project these numbers up to a statewide level. However, this sample is not representative of the statewide condition. The sample contains only 16% of the river miles in Massachusetts and these river miles consist of those that have major industrial and municipal point sources to them. It is more correct to reason that the approximately 80% of the river miles not included in the sample most likely support (or partially support) their designated uses because of the lack of known sources of pollution. Projecting these numbers upon that assumption would mean that nearly 90% of the river miles in Massachusetts support (or partially support) their designated uses. Only the enigmatic nature of nonpoint sources prevents this statement being made. However it can be reasonably argued that 90% of river miles supporting their designated uses is more likely representative of the statewide condition than the 40% of river miles meeting (or partially meeting) designated uses reported there.

The 305b report will not supply numbers that can be projected statewide until such time that a sampling program design is changed to a random method representative of the entire state and less targeted to problem areas.

The importance of the sample reported here is that it represents:

1. the major, mainstem rivers in the state. These rivers have the most flow and engage the major population centers and therefore experience the most use;

2. these rivers have been the focus of our clean up efforts over the past 25 years. Their condition reflects the magnitude and the nature of the future clean-up efforts needed.

TABLE 4.1

OVERALL USE SUPPORT

1996 ASSESSMENT

DEGREEE OF USE SUPPORT	ASSESSMENT CATEGORY EVALUATED	MONITORED	TOTAL
A.	**River & Streams (Miles)**		
Supporting	149.00	134.80	283.80
Supporting but Threatened	32.00	52.70	84.70
Partially Supporting	123.75	30.70	154.45
Not Supporting	269.85	513.95	783.80
TOTAL MILES	**574.60**	**732.15**	**1,306.75**
B.	**Lakes and Ponds (Acres)**		
Supporting	315.80	5,427.60	5,743.40
Supporting but Threatened	354.90	819.90	1,174.80
Partially Supporting	7,809.00	8,256.10	16,065.10
Not Supporting	3,594.00	3,628.00	7,222.00
TOTAL ACRES	**12,075.70**	**1,876.60**	**30,452.30**
C.	**Marine and Estuarine (sq. mi.)**		
Supporting	55.13	0.57	55.70
Supporting but Threatened	2.99	0.00	2.99
Partially Supporting	35.07	2.90	37.97
Not Supporting	94.07	27.18	121.25
TOTAL SQUARE MILES	**187.26**	**30.65**	**217.91**

Another temptation is to take the reported figures and compare them to previous 305b reports in order to establish trends. Unfortunately these data do not lend themselves to this type of scrutiny because:

1. Each year new parameters and techniques are added to the sampling program. The result of expanding coverage has usually been to detect more problem areas. These represent real impairment but do not represent a downward trend in water quality, as a side-by-side comparison of the numbers would indicate. Rather, they indicate the uncovering of previously unknown problems.

2. Each year new monitoring techniques are employed. Originally, monitoring took place in summertime, low flow conditions. The purpose was to characterize the critical conditions needed to design a wastewater treatment facility. More recently there has been a trend to monitor during rain events and high flow conditions in order to investigate emerging issues of acid rain and nonpoint source pollution. These techniques tend to reveal additional problem areas that were not apparent in traditional dry weather sampling.

3. The monitoring program is on a five year cycle. Therefore, each year new information is supplied for only 20% of the total monitoring network. There is a proposal to change the 305b reporting cycle to a five year schedule. This would better fit the monitoring cycles of most states.

In general terms the monitoring program focused on conventional pollutants in the 70's in order to facilitate the construction of wastewater treatment plants. These treatment plants were primarily designed to remove BOD, solids and control pathogens. In some cases nutrient removal was also provided. In the 80's the focus changed to monitoring and regulation of toxic pollutants. During this time there were great advancements in analytical techniques and the program was able to detect toxics with greater precision and at increasing lower levels. In the 90's emphasis shifted from point to nonpoint source remediation. This shift dictated more wet weather sampling. All of these factors combine to increase the size of "nonsupport" waters assessed that could be construed to be a downward trend in water quality by the uninformed. Instead, it reflects an increasingly sophisticated knowledge of the waters of the Commonwealth.

4.1.2 Assessment of Individual Uses

Table 4.2 summarizes individual use support for rivers. The term "not rated" refers to that portion of the total river miles assessed that were not rated for the particular water use in question.

The aquatic life use represents the primary purpose for which DEP conducts assessments. Sixty-three percent of the rivers assessed supported this use. Over half of these assessments were supported by actual biocommunity assessments conducted by DEP. These data are used, along with water column (and sediment) chemistry, and toxicity tests to determine the aquatic life use support. Of these, biocommunity data supplies the most direct evidence of a healthy, diverse aquatic life population. Since the aquatic life use carries very stringent criteria, this represents a dramatic improvement in these waters. Only a small percentage of these waters were suitable for aquatic life 25 years ago.

Fish consumption is not assessed on a routine basis; 44% of the waters assessed were not rated for this use. Where fish consumption was rated 28%

TABLE 4.2

RIVER ASSESSMENT 1996

INDIVIDUAL USE SUPPORT
(miles)

USE	SUPPORT	THREATENED	PARTIAL SUPPORT	NON SUPPORT	NOT RATED
Aquatic Life	709.70	115.90	74.85	352.10	54.20
Fish Consumption	360.80	7.60	0.00	368.30	570.05
Swimming	436.85	75.10	359.70	338.85	96.25
Secondary Contact	886.75	11.10	180.00	136.75	92.15
Aesthetics	811.10	93.60	197.00	143.80	61.25

supported the use and 28% did not support the use. The degree of nonsupport for this use is inflated by the biased sample and furthermore by the fact that more conservative assumptions are made when assessing a use that directly impacts public health. Large portions of river are often placed under an advisory on the basis of a few sampling sites. A more complete report on fish tissue contamination is presented in section 5.1 of this report.

Swimming (primary contact recreation) was supported in 39% of the water assessed. Twenty eight percent of the rivers partially support swimming. Partial support is most frequently caused by nonpoint source pollution. Under these conditions a river is swimmable under dry conditions but contaminated for a period of time after heavy rains.

Secondary contact recreation was supported in 69% of the rivers assessed. The criteria for this assessment are largely based on aesthetics although bacteria can also be used as an indicator regarding the risk of incidental contact with the water. Use support for aesthetics closely parallels secondary contact recreation which is understandable.

The analysis of individual use support reveals a consistent story regarding the recovery of national goal uses in some our most polluted waterbodies. Nearly 70% of these rivers now support aquatic life, swimming and boating; with the qualification that a portion of the swimmable waters still experience intermittent problems. This charts the success of over 25 years of clean up efforts by the Commonwealth. Approximately one fourth of the rivers assessed do not support aquatic life or swimming. It is doubtful that serious inroads into these statistics can be made without the expansion of the efforts into the fields of nonpoint source control and the reduction of toxic pollutants.

4.1.3 Causes and Sources of Impairment

Table 4.3 list the causes of impairment and the miles of rivers assessed that are impacted by each cause. Table 4.4 lists the sources responsible for impairment and the miles of river impacted by each source.

The single largest cause of nonsupport was pathogens which impacted 688.05 miles (53%) of the rivers assessed. The single largest source of nonsupport was urban runoff/storm sewers which impacted 559.4 miles (43%) of assessed rivers. This along with 174.36 miles (13%) impacted by combined sewer overflows are largely responsible for the pathogen violations. These causes and sources most usually result in nonsupport of the swimming use during and immediately after runoff events.

Municipal and industrial sources impact assessed rivers to a lesser but still significant extent (29% and 14% respectively). They may be responsible for metals, priority organics, nutrients, and organic enrichment (often resulting in low dissolved oxygen). However, major impacts from these sources are rare in Massachusetts.

Contaminated sediments impacted 275.55 miles of assessed rivers (21%). Metals, nutrients and priority organics (such as PCBs) are the most common contaminants. In extreme cases the pollution may result in a in-stream toxicity. More common is the accumulation of toxicants in fish flesh. This occurs directly with shellfish, such as mussels which are bottom dwelling filter feeders as with bottom feeding fin-fish. It occurs indirectly with predator fish. They represent the highest trophic level in the aquatic ecosystem and may further experience the biomagnification of toxicants as they are passed up through the food chain. Fish edibility advisories and an of

TABLE 4.3

RIVER ASSESSMENT 1996

CAUSES OF IMPAIRMENT

CATEGORY	MILES IMPACTED	% TOTAL
Cause Unknown	16.40	1
Unknown Toxicity	71.35	5
Pesticides	4.00	0
Priority Organics	279.80	21
Nonpriority Organics	0.40	0
Metals	341.65	26
Unionized Ammonia	37.00	3
Chlorine	22.15	2
Other inorganics	0.80	0
Nutrients	245.15	19
pH	79.80	6
Siltation	41.15	0
Organic Enrichment/DO	207.10	16
Salinity/TDS/Chlorides	24.40	2
Thermal Modifications	25.80	2
Flow Alteration	66.90	5
Other Habitat Alterations	12.80	1
Pathogens	688.05	53
Oil and Grease	4.50	0
Taste and Odor	1.20	0
Suspended Solids	101.25	8
Noxious Aquatic Plants	28.9	2
Turbidity	79.55	6

TABLE 4.4

RIVER ASSESSMENT 1996

SOURCES OF IMPAIRMENT

SOURCE CATEGORIES	MILES IMPACTED	% TOTAL
Industrial Point Sources	181.60	14
Municipal Point Sources	374.65	29
Combined Sewer Overflows	174.36	13
Agriculture	69.30	5
Urban Runoff/Storm Sewers	559.40	43
Resource Extraction	10.30	1
Land Disposal	228.35	17
Hydro-modification	78.10	6
Contaminated Sediments	275.55	21
Source Unknown	302.00	23

sediment contamination are further documented in Sections 5.1 and 5.3 of this report.

In the mid 1970's nearly half of these river miles experienced dissolved oxygen and nutrient problems and about one quarter were polluted with suspended solids and ammonia. The sources of these problems were largely untreated municipal sewage and combined sewer overflows. Today less than 20% of the river miles assessed have dissolved oxygen or nutrient problems, less than 10% have suspended solids problem and less than 5% have ammonia problems. This is largely due to the construction of municipal sewage treatment facilities. Problems remain because CSO's are just now being addressed and treatment plants constructed in the 70's and early 80's are now reaching their design life and may experience operation and maintenance problems.

Land disposal was identified as a source of nonsupport for 228.35 river miles (17%) much of this is due to failing on-site wastewater systems. Since this is one of the most difficult causal links to make under the constraints of the current monitoring system this statistic is not representative of the environmental state. It most probably understates the problem. Some portion of the "Source Unknown" category that was applied to 23% of the rivers assessed most probably is due to failing onsite wastewater systems. Furthermore since this sample is of larger rivers (more dilution) sampled most often in dry conditions (less runoff) these factors combine to make this sort of problem more difficult to detect. A monitoring program with a much greater resolution at the local level is necessary to document the extent of this source.

Our knowledge of toxicity problems in rivers continues to expand and evolve. As the conventional pollutants were cleaned up in the 1970's and early 1980's some rivers did not recover the aquatic life use as quickly as others. Toxicity was suspected. Analysis of toxic chemicals, such as metals, became more routine in the monitoring program. Analytical techniques and detection limits were improved. New methods of detecting toxicity were added to the program. Biotoxicity testing using standard test organisms became a way of screening for toxic problems even if no individual chemical toxicant was known or suspected. Other environmental compartments such as the sediments and fish flesh were able to detect toxic problems even when none were present in the water column. The ultimate ground-truth of toxic problems is the biocommunity analysis.

The river assessment shows over 340 miles of river (26%) impacted by metals and 279 miles (21%) impacted by priority organics; including such chemicals as PCB's PAH's and dioxin. Some of the metals are attributable to municipal point sources (sewage can contain copper and lead), some from nonpoint sources (road runoff can contain lead and nickel) and a portion is most probably attributable to air pollution (mercury). There is some question about the validity of the assessment because the metals criteria often appear to be overly conservative. Fortunately over half of the river miles assessed have the benefit of biocommunity analysis to aid the assessment. This resulted in 118 miles of river that would have been considered nonsupport based on the application of chemical criteria alone to be considered supporting because of healthy diverse biocommunities. The importance of this type of monitoring in order to get the most accurate possible assessment cannot be overstated.

Priority organics tend to accumulate in sediments and fish flesh because of their chemical properties. In the sediment, chemicals may accumulate over time and produce higher levels for detection. Biota are influenced not only by concentrations in the sediments and water column but by bioaccumulation within the organism and biomagnification up the food chain to top predators. Details of fish flesh and sediment contamination are found in the Public

Health section of this report. The vast majority of impacts to these environmental compartments is not believed to be due to current sources. Rather the impacts have resulted from the history of prior pollution to the rivers. An exception to this is mercury pollution which is due, at least in part, to atmospheric deposition.

4.2 Lake Assessment

4.2.1 Overall Use Support

This year's lake assessment includes 285 lakes (18,377 acres) that were monitored and 106 lakes (37,076 acres) that were evaluated. The Department has data on an additional 253 lakes (19,195 acres) on which assessments had been made in prior years, but were not used this year because the majority of data were considered too old for use in this analysis. In some cases portions of the database are used. Additionally, recent monitoring of lakes has focused on biological surveys and direct observations. The result is that not all individual uses are assessed for each waterbody and, thus, the overall use assessment is based on fewer individual use assessments.

One lake, Quabbin Reservoir, accounts for 25,000 acres, or almost half of the assessed acreage. This so skews the database that it hampers analysis. Therefore, Quabbin Reservoir is not included in the tables and charts in this report. Quabbin Reservoir supports all its designated uses (aquatic life, primary contact recreation, secondary contact recreation, aesthetics, and public water supply) with one exception. Fish consumption is not supported because levels of mercury in some fish flesh has been recorded above the FDA limit. The source of the mercury is unknown, but under study.

Excepting Quabbin Reservoir, only about 23% of the acres assessed supported their uses, about 53% of acres assessed partially supported their uses, and approximately 24% did not support their uses. The large proportion of partial support is due to the presence of non-native aquatic plants causing modification of the biological community. Other common causes of partial support are low hypolimnetic dissolved oxygen, noxious aquatic plants, or low transparency. The lake monitoring program was originally designed to assess baseline conditions on lakes and add new lakes each year to the database. Longer term studies were conducted on a relatively few lakes when resources were available. A single sampling date on many lakes makes a full temporal assessment difficult. In addition, the incremental nature of the database generated via these methods is not amenable to trend analysis and none is attempted.

4.2.2 Individual Use Support

Table 4.5 lists the support status for individual uses of lakes. Only 9% of the assessed acres support aquatic life; 27% support primary contact recreation; 59% support secondary contact recreation; and about 12% support aesthetics. In many cases a considerable portion of the acres supporting these uses is considered threatened. Although the fish consumption use category recorded the highest non-support rating for an individual category at 15%, it also represents a category that is largely not assessed (83%) because of a lack of data.

TABLE 4.5

LAKE ASSESSMENT 1996

INDIVIDUAL USE SUPPORT
(acres)

USE	SUPPORT	THREATENED	PARTIAL SUPPORT	NON SUPPORT	NOT ATTAINABLE	NOT RATED
Aquatic Life	1,889	972	15,524	526	238	11,304
Fish Consumption	339	0	6	4,707	83	25,317
Swimming	2,978	5,110	5,449	2,337	247	14,330
Secondary Contact	11,440	6,490	3,427	2,128	247	6,720
Aesthetics	2,612	1,190	557	30	83	25,981

4.2.3 Causes and Sources of Impairment

Table 4.6 lists the causes of impairment and Table 4.7 lists the sources of impairment for lakes. In order of importance the major causes of impairment are:

	Cause	% Acres Impacted
1.	Exotic (plant) species	48%
2.	Noxious aquatic plants	17%
3.	Metals	13%
4.	Organic enrichment/D.O.	6%
5.	Turbidity	5%
6.	Nutrients	4%
7.	Priority organics	3%
8.	Pesticides	<1%
9.	Flow alteration	<1%
10.	Pathogens	<1%
11.	Siltation	<1%

The major sources of non-attainment are:

	Source	% Acres Impacted
1.	Source unknown	75%
2.	Contaminated sediments	8%
3.	Land disposal	1%
4.	Urban runoff/storm sewers	<1%
5.	Construction	<1%
6.	Municipal point sources	<1%

The major cause of non-attainment is exotic plant species. This cause can be combined with noxious aquatic plants to further emphasize the dominance of this problem. Nutrients, turbidity and organic enrichment point to related and secondary effects of the primary cause. These causes, together with the top two, are indicative of eutrophication. The Commonwealth's lake assessment methods have traditionally been designed to detect these problems and had been successful in doing so. However, realizing limited resources for monitoring the Department will be focusing primarily on aquatic plant problems in the immediate future.

Although detection of toxic pollutants have not been emphasized metals are recorded as a significant cause because of their relation to fish consumption advisories. The percentage of these and other toxic pollutant impacts is likely to be low more due to methodology than lack of impact.

The sources of non-attainment are largely unknown. Again, this is attributed to technique rather than the elusive nature of sources. Lake surveys are currently designed to classify the trophic status of lakes and record obvious impacts rather than discover the source of the impacts.

TABLE 4.6

LAKE ASSESSMENT 1996

CAUSES OF IMPAIRMENT

CAUSE CATEGORY	SIZE IMPACTED (Acres)
Pesticides	171.0
Priority Organics	796.0
Nonpriority Organics	0.0
Metals	3,937.0
Nutrients	1,228.5
Siltation	9.0
Organic Enrichment/D.O.	1,840.3
Flow Alteration	157.0
Pathogens	16.0
Suspended Solids	0.0
Noxious aquatic plants	5,246.3
Turbidity	1,426.5
Exotic Species	14,530.5

TABLE 4.7

LAKE ASSESSMENT 1996

SOURCES OF IMPAIRMENT

SOURCE CATEGORIES	SIZE IMPACTED (acres)
Municipal Point Sources	22.0
Agriculture	0.0
Construction	46.0
Urban Runoff/Storm Sewers	219.2
Land Disposal	326.1
Hydro-modification	0.0
Source Unknown	22,900.3
Other	0.0
Contaminated Sediments	2,506.3
Natural	0.0
Recreational Activities	0.0

4.2.4 Trophic Status of Lakes

In addition to use support assessments, the Commonwealth assesses the trophic status of lakes. Since the last reporting cycle 94 lakes have been added to the database of lakes and ponds surveyed. In addition, new monitoring data were obtained for many of the lakes listed previously as not assessed. Currently 664 lakes have been surveyed since the Massachusetts lake monitoring program began in 1974. Of these, 391 are assessed this cycle (up from 210 two years ago).

TROPHIC ASSESSMENT SUMMARY

Assessed Trophic Status	Acres	# of Lakes
Dystrophic	0	0
Hypereutrophic	2,857	54
Eutrophic	14,032	225
Mesotrophic	12,665	114
Oligotrophic	25,952*	9
TOTALS	55,506*	402

Unknown Acres = 151,173 - 55,506* = 95,667
Lakes/Ponds Not Assessed = 3191 - 402 = 2789

* Includes the Quabbin Reservoir (25,000 acres)

Historically the Commonwealth, through the Department of Environmental Protection, used a lake/pond classification system that relied on assigning severity points to six (6) parameters (Secchi disk transparency, hypolimnetic dissolved oxygen, epilimnetic total phosphorus, epilimnetic inorganic nitrogen, phytoplankton counts, and aquatic macrophyte density). Unfortunately, this system was inconsistent, particularly in the cases of shallow, macrophyte-dominated lakes and so has been abandoned. The first step toward revising the assessment/classification process has been taken with the completion of a document by the U.S. Environmental Protection Agency, Environmental Research Laboratory (using EPA Clean Lakes Program lake Water Quality Assessment grant funds) that delineates detailed sub-ecoregion maps for Massachusetts. Currently, data have been collected and are being analyzed in three subregions to determine if these subregion delineations are valid. If they are valid further validation of other subregions should be attempted. Ultimately, the validated subregions will become the basis for new procedures that will give a more realistic picture of the Commonwealth's lake quality, trends in eutrophication, use attainability by subregion, and potential for success in future lake management efforts.

In the interim, trophic status assessments for this report are based primarily on best professional evaluation of the data available rather than the old classification system. Since this is essentially the same procedure that has been used since the 1990 Summary of Water Quality Report, the assessments are comparable. As in the 1990-1994 reports there is a tendency for skewing of data (excluding the Quabbin Reservoir) toward eutrophic and hypereutrophic lakes (enriched lakes exhibiting severe use impairment and ecosystem degradation) because older data are more likely to be retained for assessments in these categories, whereas those in the mesotrophic (moderately enriched) and oligotrophic (nutrient poor) categories are less likely to be retained. Once again this year the Quabbin Reservoir is included in the assessment. The inclusion of this large, water supply reservoir continues to significantly

skew the assessment of acreage toward oligotrophic when, in fact, with so few lakes assessed (only about 13%) it is unrealistic to project the current condition of lake resources statewide.

4.2.5 Restoration Efforts

Federal Clean Lakes Projects

The Commonwealth is mandated by the Federal Water Pollution Act to restore and maintain the chemical, physical and biological integrity of waters within the Commonwealth. Section 314 of the Clean Water Act established policies and procedures by which the Commonwealth may enter into cooperative agreements to restore publicly owned freshwater lakes and ponds and protect them against degradation.

As a result of state legislation passed in 1992 responsibility for administration of federal Clean Lakes Program grants was transferred to, and currently rests with, the Department of Environmental Management (DEM).

State Clean Lakes Program

The purpose of the program has been to restore, preserve or maintain the Commonwealth's publicly owned lakes and ponds for recreation and enjoyment.

The goals of the program are threefold:

a) To diagnose degraded lakes and ponds and implement, on a priority basis, long-term solutions for the purpose of restoring their water quality. These long-term solutions must be shown to be feasible, cost-effective, and environmentally sound.

b) To diagnose lakes and ponds and implement, on a priority basis, methods for the long-term preservation of their water quality. This long-term preservation program must be shown to be feasible and cost-effective.

c) To provide short-term remedial actions, on a priority basis, that relieve severe problems of nuisance aquatic macrophyton and/or phytoplankton and that maintain water quality conditions adequate for public recreation and enjoyment.

A further description of the program may be found in the Clean Lakes Program Guidelines (revised April 1989). Seven (7) projects are continuing to proceed under DEM administration using funds encumbered in previous fiscal years.

With limited resources available for administering the Commonwealth's Clean Lakes Program over the last five years efforts to retard eutrophication have shifted to the federally supported Nonpoint Source Program and on local initiative. Beginning in 1994 the DEM initiated the Lake and Pond Grant Program that provides up to $10,000 matching (50%) grants for a variety of activities including lake and watershed management and development/enhancement of public recreation/access facilities. From 1994 through 1996 $686,000 in grants have been awarded for 95 lakes/ponds. However, given the intensity of development in the Commonwealth these limited efforts have had little effect in changing the negative trend over the last few years.

4.2.6 Impaired/Threatened Lakes and CWA Goals

Of the 3191 lakes and ponds in the state, 391 were assessed this year by the Department. Of these lakes (90%) are considered impaired or threatened. Overall, metals (particularly mercury in fish tissue) are the greatest cause of impairment when the Quabbin Reservoir is factored into use impairment. The fish consumption ban there acts to skew the overall assessment. For the remaining lakes in Massachusetts dense macrophyte growths (including non-native, invasive plant species) and/or algal blooms, low transparency anoxia (particularly in the hypolinmion) nutrients are the most common causes of impaired or threatened uses.

Although specific sources of pollutants in individual Massachusetts lakes are largely unassessed or unknown, much is known about the generic sources of contaminants in lakes. Where assessments have been made, "contaminated" sediments (oxygen demand from decomposition of organic sediments), onsite wastewater systems (reflected in the land disposal category), and stormwater runoff are most commonly noted. Although direct point discharges to lakes are almost nonexistent, data from several impoundments along the Ten Mile River and French River systems indicate that upstream wastewater discharges have had significant impacts on them.

As with other lake assessments in this report the non-support status of the Quabbin Reservoir - because of a fishing ban - skews the overall assessment. Yet, even without the Quabbin Reservoir data the assessment (Table 4.1) clearly indicates that a majority of the lakes in Massachusetts are only partially supporting their designated uses or are threatened.

4.2.7 Acid Deposition Effects on Lakes

Acid Deposition Monitoring

The Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement (MDFWELE) uses the following three categories, based on total alkalinity values, to determine a lake's susceptibility to acid inputs.

CATEGORY	TOTAL ALKALINITY ($CaCO_3$)
Vulnerable	>5 - 10 mg/l
Endangered	>2 - ≤ 5 mg/l
Critical	≤2 mg/l

For the 1990 Water Quality Summary Report a database of broader scope was provided from the Acid Rain Monitoring (ARM) Project; a volunteer citizen monitoring program coordinated by the Water Resources Research Center at the University of Massachusetts. That program, which monitored lakes and streams on a quarterly basis, provided information on over 2,000 lakes monitored from 1985 to 1989 (Walk, personal communication, 1990). Their records indicated that 515 fell into the "critical" category, 398 were "endangered," and 432 were considered "vulnerable." No more recent data have been reviewed to determine current conditions relating to acid deposition.

Acid Deposition Mitigation

The Massachusetts Generic Environmental Impact Report, Statewide Liming of Acidified Waters (1985) stresses that "... the addition of ground limestone is the most biologically, socially and economically acceptable method for mitigating this problem (high acidity)." In developing a program to lime

affected lakes the MDFWELE developed the following set of nine criteria for selecting lakes to treat:

1) total alkalinity 2 ppm or less;
2) treat only great ponds or waters with a legal public access;
3) dystrophic lakes are excluded from treatment;
4) the lake's retention time must be a year or more;
5) metals concentrations must be below toxic levels;
6) the lake bottom cannot be dominated by mud or organic matter;
7) the mean depth must be eight feet or more and the maximum depth must be eighteen feet or more for a normal dose;
8) all waters must be screened by the Natural Heritage Program for rare and endangered species; and
9) liming must be the most cost-effective treatment.

N.B. -- One exception to these criteria is that waterbodies with "put and take" sport fisheries or fisheries of important genetic stocks may be treated even if they do not meet all of the above criteria.

From 1987 through 1989, the MDFWELE, in conjunction with Living Lakes, Inc., a private corporation, limed five lakes. During 1991 nine lakes were treated or retreated by Living Lakes, Inc., but since then no liming activities have been undertaken by MDFWELE. Future plans for such activities are uncertain.

4.2.8 Toxic Control

As stated in the liming selection criteria, the MDFWELE will not lime a lake if metal concentrations are above toxic levels. To date neither the MDFWELE nor the Department have developed mitigation methods or established plans to control toxics or metals mobilized by high acidity. Both agencies have limited sampling programs to monitor toxics in the environment and these programs are designed to stress the public health concerns of environmental toxics by focusing on locating areas of high concentrations and limiting the discharge of toxics to prevent toxic mobilization.

4.2.9 Toxic Effects on Lakes

Since the major thrust of the Massachusetts Lake Monitoring Program has always focused on nutrient loading and eutrophication, the toxicity assessments have been made utilizing information from other programs; primarily from the Department's Biological Monitoring Program (part of the Division of Watershed Management), including fish tissue analyses and basin wide health advisories. Toxicity results reported in Section 5.1 have been obtained from these sources.

Forty-four (44) lakes are reported in this assessment cycle as having toxicity problems. Of these, thirty-seven (37), including Quabbin Reservoir, result from mercury toxicity in fish tissue. In five (5) lakes PCBs are the cause of toxicity; two of these lakes are also listed for mercury. The four (4) remaining cases are listed for PAHs, chlorodane, pesticides, and dioxin, respectively. In all cases fish consumption advisories or bans are in effect.

4.3 Marine Assessment

Marine waters can be divided into harbors, bays, estuaries and open ocean areas. The Division of Marine Fisheries assesses 1,876 square miles of these waters for the shellfishing use. These results are reported separately in Section 5.4 of this report.

DEP's assessment includes 244 square miles of harbors, bays and estuaries; but generally excludes open ocean waters. The areas assessed are relatively near shore and target known areas of pollution. Therefore the shellfishing use is assessed for a much more extensive area than the remaining uses; but cause and source information is available only for DEP's relatively small and biased subsample of these waters.

4.3.1 Use Support

Overall use support for marine waters is listed in Table 4.1. Only 44% of the assessed waters fully or partially supported their designated uses. This is not representative of the entire Massachusetts coast. Nearly half of the total area assessed is within The Boston Harbor, Buzzards Bay and North Shore drainage areas; which historically have been areas of severe impacts.

Table 4.8 lists individual use support for marine waters. Aquatic life is supported in half (50%) of the assessed waters. Unlike the river assessment much of the analysis relies on water chemistry to make this determination because biological data is unavailable. Primary and secondary contact recreation is supported or partially supported in over 86% of the waters assessed (partial use refers to impairment that is neither frequent or prolonged). Fish consumption is not rated in 79% of the waters assessed but where it was assessed it generally did not support the use. This is attributed to the targeting of the program toward known trouble spots.

The shellfishing use assessment gives a truer picture of the overall quality of the entire Massachusetts Coast. The area assessed is nine times larger than the area used in the other assessments and the shellfishing use demands extremely high quality water to be supported. In this analysis only 9% of the assessed waters did not support the use while 78% supported the use. A considerable percentage (12%) were not sampled and therefore could not be rated. Given this information, it appears that the waterbody system underestimates use support in relation to open ocean waters.

4.3.2 Causes and Sources of Impairment

Causes of Impairment are listed in Table 4.6 and Sources of Impairment in Table 4.7. Bacterial contamination (pathogens) impact over two thirds of the marine waters assessed and are by far the leading cause of nonsupport. A major source of bacterial contamination is stormwater, which impacts nearly 50% of the assessed waters. Another source is combined sewers which adversely affect one third of the waters assessed. Organic enrichment and ammonia impact one quarter of the waters assessed and are often the result of municipal point sources and/or combined sewers overflows. Over 40% of the assessed waters are impacted by unknown sources. This is sometimes due to the diffuse nature of nonpoint sources and sometimes due to the difficulty of determining causes and effect among multiple causes and sources.

Toxicity to aquatic life is evidenced by the impacts of priority organics, metals and ammonia. It is estimated that nearly half of the toxicity in marine waters is due to sediments contaminated with priority organics and metals. CSO's, nonpoint sources, and municipal point sources also contribute to the problems. The clean up of municipal point sources to marine waters is well underway but more work is needed to complete the task. Major rehabilitation of the sewerage system in Boston has resulted in fewer combined sewer overflows and better treatment at the Deer Island facility. Additional improvements including secondary treatment and an extended outfall are under construction.

TABLE 4.8

MARINE ASSESSMENT 1996

INDIVIDUAL USE SUPPORT
(square miles)

USE	SUPPORT	THREATENED	PARTIAL SUPPORT	NON SUPPORT	NOT RATED
Aquatic Life	107.25	1.77	24.20	63.37	21.32
Fish Consumption	0.00	0.00	0.00	45.45	172.46
Swimming	99.64	0.10	90.13	15.47	12.57
Secondary Contact	185.52	0.00	10.00	9.99	12.40
Aesthetics	151.28	10.23	26.23	8.29	21.63

TABLE 4.9

MARINE ASSESSMENT 1996

CAUSES OF IMPAIRMENT

CAUSE CATEGORY	SQUARE MILES IMPACTED	% TOTAL
Cause Unknown	6.20	3
Priority Organics	40.95	19
Nonpriority Organics	4.10	2
Metals	43.02	20
Unionized Ammonia	53.87	25
Chlorine	3.13	1
Nutrients	24.53	11
Organic Enrichment/Low D.O.	51.53	24
Pathogens	150.13	69
Oil and Grease	8.10	4
Taste and Odor	8.60	4
Noxious Aquatic Plants	7.81	4
Turbidity	8.10	4

TABLE 4.10

MARINE ASSESSMENT 1996

SOURCES OF IMPAIRMENT

SOURCE CATEGORIES	SQUARE MILES IMPACTED	% TOTAL
Industrial Point Sources	10.99	5
Municipal Point Sources	74.09	34
Combined Sewer Overflow	71.92	33
Agriculture	4.64	2
Urban Runoff/Storm Sewers	105.99	49
Land Disposal	15.63	7
Marinas	2.00	1
Contaminated Sediments	38.45	18
Source Unknown	88.77	41

4.3.3 Eutrophication

In most coastal waters the essential nutrient nitrogen typically limits the growth of aquatic plants (including phytoplankton, epiphyton, macro-algae and submerged aquatic vegetation). Excess inputs of nitrogen from human activities results in many negative impacts to coastal waters, primarily related to the stimulation of excessive plant growth. Increased abundance of phytoplankton can limit the transmission of light reaching eelgrass leaves, resulting in loss of eelgrass beds (that provide habitat for shellfish and other animals).Accumulations of dense layers of macroalgae on the bottom of shallow embayments can exclude shellfish and other invertebrates. Increased plant matter can also result in high respiration at night or in the lower, dark layers of the water column (lowering the concentration of dissolved oxygen); and the decay of plant matter further depletes the dissolved oxygen in water column.

Hypoxia and Anoxia

Hypoxia, the condition in which dissolved oxygen (DO) concentrations are lowered to 3.0 ppm or less, is cause for concern in surface waters because it negatively impacts biological communities, and it can be a precursor to a more serious condition, anoxia, the total loss of DO in the water column.

Anoxia most often occurs in the sediments and along the very bottom of the water column during worst case condition. General water column surveys are not designed to detect this condition, so the fact that anoxic conditions are not often reported does not necessarily imply that they are not occurring. Anoxic conditions have been detected in Mount Hope Bay (part of the Narragansett Bay system) and Waquoit Bay on Cape Cod.

Available data indicate that hypoxic conditions are infrequent, short-lived events in Massachusetts waters. Hypoxia most often occurs in Boston Inner Harbor, but has also been detected in Dorchester Bay, the Neponset River, Mount Hope Bay, Buzzards Bay in New Bedford Outer Harbor, and Waquoit Bay and its tributaries.

Algal Blooms

Algal blooms in Massachusetts coastal waters can be short-lived and quite localized, making their detection difficult. Such blooms, presumably occurring in response to brief nutrient loading incidents such as rainstorms have, however, been observed. Unfortunately, there are longer-lived, and sometimes geographically extensive, bloom conditions that recur each year. A notorious example is the Pilayella bloom that annually fouls the beaches of Nahant Bay and Broad Sound. This bloom constitutes a serious, and apparently growing, aesthetic and recreational problem in these areas. Once confined to parts of Nahant Bay, it has nearly doubled in extent over the last decade and is now inundating all of the beaches in inner Broad Sound. On the South Shore, Cape Cod and embayments and estuaries of Buzzards Bay, summertime blooms of Ulva and Chodium are regular events. During the Spring of 1992, a dense, widespread bloom of Phaeocystis was reported on the North Shore in the vicinity of Gloucester. For the last several years the occurrence of blooms of various species of algae have been reported off Cape Cod, often resulting in localized aesthetic impacts to beaches. Of the most concern, with regard to public health, are the blooms along the North Shore (and more recently along the South Shore) of the red tide organism Alexandrium fundyense that result in paralytic shellfish poisoning. It should be noted, however, that the cause of the blooms of this organism is not known, and seems to be related more to salinity, temperature, and possibly water column iron concentrations,

than simply to nutrient inputs. For this reason it would be misleading to include a discussion of this phenomenon in a section on nutrient loading.

Nutrient Loading

Nitrogen enters coastal waters from a wide variety of sources, including point sources such as wastewater treatment plants and industrial discharges, and non-point sources such as combined sewer overflows, residential and agricultural runoff, groundwater flows, and atmospheric deposition. Although the quantification of loading from all these sources is not an exact science, several attempts have been made to estimate loading to large segments of the Massachusetts coastal waters: most notably for Massachusetts and Cape Cod Bays (Menzie-Cura, 1991), and for Buzzards Bay (SAIC, 1991). Menzie-Cura indicated that point source discharges account for 43 to 66 percent of the total nitrogen loading, river discharges account for 37 percent, atmospheric deposition accounts for 16 percent, and surface runoff accounts for 11 percent. The report also states that groundwater is an especially important source of nitrogen for the nearshore waters of Cape Cod. In the case of Buzzards Bay, point sources account for an estimated 62 percent, septic systems for 14 percent, atmospheric deposition for 13 percent, agricultural runoff and inputs from cranberry bogs for 5 percent, and lawn fertilizer and runoff from developed land for 6 percent.

4.3.4 Habitat Modification

Massachusetts is estimated to have lost approximately 30 % of the total wetland acreage and 20 % of coastal wetland acreage existing at the time of the colonists. The Massachusetts Audubon Society (1991) reports that another 1,000 acres, or nearly 0.2 % of the state's remaining coastal and inland wetlands are lost annually. Although Massachusetts has enacted the Wetlands Protection Program allowable projects have resulted in continued incremental losses due to development, both public and private, and secondary alterations. It is the cumulative effect of these activities that reduces valuable habitat. The combined effects of habitat encroachment and degraded water and sediment quality stresses all marine organisms, including important commercial species, marine mammals, and the food web on which they depend. Several programs that have the potential to fill gaps in the Wetlands Protection Program, such as the Wetland Conservancy Program and the Wetlands Restoration and Mitigation Bank, will be discussed in detail in Section 3.6 (Wetlands Assessment).

4.3.5 Living Resources

In a summary on resource depletion the Massachusetts Bays Programs 1991 Comprehensive Conservation and Management Plan, or CCMP, (MBP, 1991) states that while habitat loss diminishes both the quantity and quality of coastal and marine resources, direct depletion of resources through overharvest is also of concern in the region. Fishery stocks rebounded temporarily (after enactment of the Magnuson Fishery Conservation and Management Act of 1976, intended to relieve foreign fishing pressures) before an increase in the number of U. S. fishing boats, with sophisticated fishing technologies, strained the fishery again. The CCMP goes on to state that commercial landings of many species in Massachusetts and offshore waters have plummeted to record lows. Massachusetts mimics the New England-wide trend, with haddock landings down 77% since 1978, Yellowtail flounder down 56%, winter flounder 47%, and Atlantic Cod 38%. Species diversity and relative abundance have been altered, so there is a significant ecological impact accompanying this economic impact. Sharks, skates, and dogfish have replaced the valuable groundfish, which now comprise less than 50 % of the bottom biomass.

Populations of pelagic species (Atlantic bluefin tuna, sharks, and billfish) are also declining due to over fishing and environmental pressures.

4.3.6 National and State Programs

Massachusetts is currently participating in two National Estuaries Programs: 1) Massachusetts Bays Program, and 2) Buzzards Bay Project. Massachusetts is also participating in the Gulf of Maine Program in a collaboration with Maine, New Hampshire, Nova Scotia, and New Brunswick. The general goals and approach of the programs is similar in that they combine local, state, and federal agency resources, with citizen and academic participation, to identify problem areas, investigate and prioritize corrective actions (which might include conducting research and monitoring), fund and initiate corrective projects, as well as strengthen and focus long-term management efforts aimed at conserving the ecosystems of each of the bays and the Gulf of Maine.

4.3.7 A Case Study

The Narragansett Bay system, which includes Mount Hope Bay, receives thermal discharges, municipal and industrial wastes, and non-point source runoff from both Rhode Island and Massachusetts, including a significant annual loading from the combined sewer overflows of the City of Fall River. Historical data on Mount Hope Bay indicated that there were periods of time when the dissolved oxygen concentrations in the lower levels of the water column fell below that permitted by the Massachusetts Water Quality Standards. Given the shallowness of the Bay and the nature of the watershed (i.e., significant source of nutrient loading) it was considered a likely site for nutrient enrichment and related impacts (including low dissolved oxygen). A large-scale study conducted in 1991 by the Department's Marine Program confirmed low dissolved oxygen events in the Bay.

The results of the two and a half month field monitoring study in Mount Hope Bay indicated that there are infrequent periods during the summer months in which dissolved oxygen concentrations in the bottom waters of the northwestern parts of the bay reach zero (a condition known as anoxia). More frequently, and more widespread, the D.O. concentration reaches 3 mg/l, a condition known as hypoxia, which is extremely harmful to the aquatic biota. Indications are that the excess phytoplankton production, due to nutrient enrichment, is responsible for the dissolved oxygen problems in the bay.

In order to combat the D.O. problem, as well as impacts due to the addition of bacteria to the Bay, a Combined Sewer Overflow (CSO) Facilities Plan was initiated by Fall River. Dry weather overflows were immediately corrected by an intense inspection, repair, and maintenance program performed by the City. The results of studies and modeling of the entire system was a proposal to restructure the sewer system, including the construction of a 20' diameter storage tunnel 4.5 miles in length. The benefits of this proposed action are as follows:

- Storage of combined sewage for a 3-month storm
- 19 CSO locations reduced to 1 "extreme" event overflow location in Mount Hope Bay
- A 75% reduction in CSO volume
- An average of 662 annual CSO events reduced to 4 events per year

- Chlorination/dechlorination and solids/floatables removal of the extreme event overflow.

Although the loading from the Fall River combined sewer overflows are only a part of the problem, the reductions in loading to the Bay, that will be achieved by the proposed plan, will result in significant improvements in the water quality of Mount Hope Bay. A major challenge left for local, State, and Federal agencies is to determine remaining sources of pollutants to the system, and develop means of implementing corrective actions. Continued monitoring of the Bay by the Department's Marine Program will be instrumental in determining future conditions resulting from any corrective actions that might be taken.

5.0 PUBLIC HEALTH/AQUATIC LIFE IMPACTS

5.1 Fish Tissue Contamination

Fish consumption advisories are issued to protect the public from ingesting harmful quantities of toxic pollutants in contaminated fish and shellfish. Massachusetts fish consumption advisories are issued by the Department of Public Health (DPH).

The Fish Toxics Monitoring and Assessment Program is a freshwater sampling, analysis and evaluation program headed by DEP in cooperation with DPH and the Department of Fish and Wildlife and Environmental Law Enforcement. (DFWELE). In this program DEP conducts the sampling and analysis while DPH determines the health impacts of fish consumption. All three agencies participate in the overall planning, including the prioritization of testing sites, publication of the fish toxics data and their use in assessing the health of aquatic ecosystems.

Individual fish consumption advisories are tailored to minimize health risks based on the local contaminant data collected. Advisories may recommend no fish consumption in severely polluted waters or limit fish consumption to several meals per month in cases of less severe contamination. Advisories may target a sub-population at risk (such as children under 12 years old, pregnant women and nursing mothers), specific fish species that concentrate toxic pollutants in their flesh, or larger fish within a species that may have accumulated higher concentrations of a pollutant than a smaller, younger fish.

Table 5.1 lists the current freshwater fish advisories for Massachusetts for this reporting period. Forty-one of these advisories (70%) are due to mercury contamination and 15 advisories (26%) are due to PCB contamination. There are two advisories for pesticides and one for PAH. The overwhelming majority of advisories (96%) are for two contaminants. The sources of PCB's have been traced to historical sources that no longer discharge these substances to Massachusetts waters. The mercury is suspected to be due largely to atmospheric transport and deposition and is discussed further below.

Boston Harbor

The Massachusetts Department of Public Health issued the following advisory concerning consumption of seafood from Boston Harbor, including Quincy Bay. The recommendations are specific for fishery products from Boston Harbor, with the exception of lobster tomalley which should be avoided regardless of its source.

Lobster Tomalley - All persons should eliminate consumption of the lobster tomalley (liver). This is the soft green substance found in the tail and body section of the lobster. This recommendation applies to tomalley from lobsters from any source due to the finding of abnormally high chemical contaminant levels in tomalley from lobsters from a number of different geographic locations.

Boston Harbor Fishery Products - Pregnant and breast-feeding women, women who intend to become pregnant, children under the age of 12, and individuals with lowered immunity should avoid consuming certain fishery products from Boston Harbor. This applies to lobsters, flounder, soft-shell clams and other bivalves. This precaution is being recommended to provide an added measure of protection for those individuals who may be more sensitive to chemical and microbiological contaminants, or to the unknown factors which may be causing histopathologic abnormalities in the Boston Harbor fishery products.

TABLE 5.1

FRESHWATER FISH ADVISORIES

Basin/Waterbody		Advisory/Species	Contaminant
Hoosic	- Hoosic River N. Adams-Williamstown	P6-All	PCBs
Housatonic	- Housatonic River (1) Dalton-Sheffield	P1, P2-Frogs, Turtles, Fish	PCBs
	- Pontoosuc Lake Pittsfield, Lanesborough	P1-LMB, P3-LMB	Mercury
Deerfield	- Sherman Reservoir Rowe, Monroe	P1, P2-YP, P4	Mercury
	- Plainfield Pond Plainfield	P1-LMB, P3-LMB	Mercury
Connecticut	- Connecticut River Northfield, Longmeadow	P1, P2-CC, WC, AE, YP	PCBs
Millers	- Gales Pond Warwick	P1-YP, P3-YP	Mercury
	- Lake Rohunta Orange, Athol, New Salem	P1, P5	Mercury
	- Millers River below Otter River Erving to Winchendon	P1, P2-BT, AE, P4	Mercury, PCBs
	- Otter River within ½ mile of Millers River Templeton, Winchendon	P1, P2-WS, BB	PCBs
	- Upper Naukeag Lake Ashburnham	P1-SMB, YP, P3-SMB, YP	Mercury
	- Upper Reservoir Westminster	P1, P5	Mercury
Chicopee	- Powder Mill Pond Barre	P1, P5	Mercury
	- Quabbin Reservoir (2) New Salem	See note (2)	Mercury
	- Quaboag Pond E. Brookfield, Brookfield	P1, P2-LMB, P4	Mercury
	- South Pond Sturbridge, Brookfield	P1, P5	Mercury
Nashua	- Grove Pond (3) Ft. Devens, Ayer	P6	Mercury
	- Mirror Lake Ft. Devens, Harvard	P1-LMB, P3-LMB	Mercury
	- Pepperell Pond Pepperell, Groton	P1, P2-LMB, P4	Mercury
	- Plowshop Pond (4) Ft. Devens, Ayer	P6	Mercury

TABLE 5.1 (CONTINUED)

FRESHWATER FISH ADVISORIES

Basin/Waterbody		Advisory/Species	Contaminant
Nashua (Cont.)	- Wachusett Reservoir (2) Boylston	See note (2)	Mercury
Blackstone	- Blackstone River above Blackstone Gorge	P1, P2-C, WS	PCBs
	- Mill River Milford Area	P1, P5	PCBs
	- Rice City Pond Uxbridge, Northbridge	P1, P2-C	PCBs
	- Riverdale Pond Northbridge	P1, P5	PCBs
	- Waite Pond Leicester	P1, P5	Mercury
Merrimack	- Merrimack River Tynsborough, Methuen	P1-WS, LMB, P3-WS, LMB	Mercury
Concord	- Concord River Concord, Billerica	P1, P2-LMB, P4	Mercury
	- Heard Pond (5) Wayland	P6	Mercury
	- Lake Cochituate Framingham, Natick, Wayland	P1, P2-AE	PCBs
	- Hocomonco Pond Westborough	P6	PAHs
	- G.H. Nickols A-1 Site Westborough	P1, P2-LMB	Mercury
	- Puffers Pond (3) Ft. Devens Annex, Sudbury	P6	Mercury
	- Sudbury Reservoir Marlboro	P1, P2-Bass	Mercury
	- Sudbury River (5) Ashland, Concord	P6	Mercury
	- Walden Pond Concord	P1-LMB, SMB, P3-LMB, SMB	Mercury
Shawsheen	- Shawsheen River Ballardvale Impoundment Andover	P1-LMB, BC, P3-LMB, BC	Mercury
Parker	- Pentucket Pond Georgetown	P1, P2-LMB, BC, P4	Mercury
Ipswich	- Martins Pond North Reading	P1-LMB, BC, YP, P3-LMB, BC, YP	Mercury

TABLE 5.1 (CONTINUED)

FRESHWATER FISH ADVISORIES

Basin/Waterbody		Advisory/Species	Contaminant
Boston Harbor	- Clay Pit Pond Belmont	P6	Chlordane
	- Neponset River Walpole, Hyde Park	P1-BB, P3-BB	PCBs
	- Willet Pond Walpole, Norwood, Westwood	P1-LMB, P3-LMB	Mercury
	- Cochato River Braintree	P1, P2-BB, C, AE, P4	Pesticides
	- Sylvan Lake Holbrook	P1, P2-BB, C, AE, P4	Pesticides
Charles	- Cedar Swamp Pond Milford	P1, P5	Mercury
	- Charles River (Lochrane Dam, Natick to Museum of Science Dam, Boston) Boston, Cambridge, Dedham, Dover, Natick, Needham, Newton, Watertown, Weston, Wellesley, Waltham	P1-C, P3-C	PCBs
	- Lake Winthrop Holliston	P6	Dioxin
	- Muddy River Boston, Brookline	P1, P2-BB, C, AE, P4	PCBs
South Coastal	- Drinkwater/Indian Head River and Factory Pond (6) Hanson, Hanover, Pembroke	P6	Mercury
Cape Cod	- Mashpee/Wakeby Pond Mashpee, Sandwich	P1-SMB, P3-SMB	Mercury
	- Wequaquet Lake Hyannis	P1-LMB, P3-LMB	Mercury
Islands	- Gibbs Pond Nantucket	P1, P5	Mercury
	- Miacomet Pond Nantucket	P1, P2-WP, P4	Mercury
Buzzards Bay	- Copicut River, Cornell Pond Dartmouth	P1, P2-AE, P3-LMB	PCBs Mercury
	- Noquochoke Lake Dartmouth	P1, P2-LMB, AE, P4	Mercury, PCBs
	- Snipituit Pond Rochester	P1-BC, LMB, P3-BC, LMB	Mercury
	- Turner Pond Dartmouth, New Bedford	P1, P5	Mercury

TABLE 5.1 (CONTINUED)

FRESHWATER FISH ADVISORIES

Basin/Waterbody		Advisory/Species	Contaminant
Taunton	- Somerset Reservoir Somerset	P1-LMB, P3-LMB	Mercury

Advice Codes:

P1 = Children < 12, pregnant women & nursing mothers should not eat fish from this waterbody.
P1-species = Children < 12, pregnant women & nursing mother should not eat any affected species from this waterbody.
P2-species = The general public should not consume any affected fish species from this waterbody.
P3-species = The general public should limit consumption of affected fish species to 2 meals/month from this waterbody.
P4 = The general public should limit consumption of non-affected fish species to 2 meals/month from this waterbody.
P5 = The general public should limit consumption of all fish from this waterbody to 2 meals/month.
P6 = The general public should not consume any fish from this waterbody.

Fish Codes:

AE=american eel; BB=brown bullhead; B=bluegill; BC=black crappie; BT=brown trout; C=carp; CC=channel catfish; CCS=creek chubsucker; CP=chain pickerel; FF=fallfish; LMB=largemouth bass; LNS=longnose sucker; SMB=smallmouth bass; WC=white catfish; WP=white perch; WS=white sucker; YP=yellow perch

Hazard Code:

PCBs = Polychlorinated biphenyls
PAHs = Polycyclic aromatic hydrocarbons

Notes:

(1) Fish taken from feeder streams to the Housatonic River should be trimmed of fatty tissue prior to cooking.
(2) Children < 12, pregnant women and nursing women should not consume fish **EXCEPT** for lake trout (<24 inches) and salmon. All other people should not eat the affected species; may eat unlimited amounts of salmon and lake trout <24 inches; and limit consumption of all Quabbin and Wachusett Reservoirs fish to one (5 oz.) meal/week.
(3) U.S. Army issued advisories.
(4) Municipality issued advisory.
(5) Sudbury River Fish Consumption Advisory pertains to the extent from Ashland to the confluence with the Assabet and Concord Rivers and includes the Stern and Bracket Reservoirs in Framingham.
(6) Factory Pond Advisory has been updated October 1995 to include the Drinkwater River/Indian Head River.

There were multiple reasons for these advisories including chemical, microbiologic, and parasite contaminants and histopathologic abnormalities.

Other Targeted Advisories

New Bedford Harbor - In 1986 regulations were promulgated by DPH prohibiting the taking or sale of lobsters and certain fish (bottom feeders) from New Bedford Harbor. The regulations (105 CMR 260) define three separate areas with associated prohibitions. The reason for the prohibition is PCB contamination from a nearby superfund hazardous waste site.

Bluefish - in November of 1983 DPH issued and advisory for pregnant and breast-feeding women and those who are considering becoming pregnant not to eat bluefish because of PCB contamination. The advisory also cautions moderate to heavy eaters of bluefish to take certain measures to reduce PCB levels in the bluefish they eat. These include removing skin, fatty tissue and dark meat before cooking and broiling fish instead of frying to allow as much as the fat as possible to be drained away.

Statewide Advisory for Mercury

Mercury - based on the review of limited data DPH recommended that pregnant women should refrain from consumption of freshwater fish from Massachusetts waterbodies in order to prevent exposure of developing fetuses to mercury. The recommendation is considered a precautionary measure which should be taken until such time as additional data can be analyzed. The recommendation was based on testing of only 73 of the state's over 5,000 waterbodies. Albeit limited evidence a conservative approach is being taken. The general public is not considered to be at risk from fish consumption, but pregnant women should consult their physicians concerning their specific circumstances. In this regard DPH has initiated an education and outreach program to alert the state's medical community about the health concerns relating to the consumption of some freshwater fish by pregnant women.

The largest source of mercury contamination is air emissions, particularly from incineration of wastes that contain mercury, power plants burning coal or mercury-containing products and industrial facilities that use mercury in their process. Once released into the atmosphere, mercury can be deposited in waters around a facility or transported over long distances and deposited in water directly or through runoff. Once in the water the mercury is converted to methyl mercury which is highly toxic and accumulates in fish flesh.

5.2 Fish Kills and Abnormalities

The Massachusetts Division of Fisheries and Wildlife reported 74 fish kills during the period of January 1, 1994 and December 31, 1995 involving an estimated 44,059 fish. Most fish mortality (71%) was due to two major kills that resulted from alum and chlorine contamination respectively. Disease accounted for and additional 12 percent of the mortality.

Most of the fish kills occur during the warmer months of May through August, usually peaking in May with spawning activity and rapid warming of the water; conditions conducive to increased stress and bacterial infections. Disease continues to be the primary cause of fish kills. Most disease related kills occur in lakes that have been impacted by excess nutrients. Nutrient enrichment may also be due to a secondary affect of diurnal or seasonally low oxygen levels which induce stress and make fish more susceptible to bacterial infections. Table 5.2 summaries the fish kill data for the reporting period.

TABLE 5.2

FISH KILL DATA

JANUARY 1, 1994 - DECEMBER 31, 1995

CAUSE	NUMBER OF INCIDENTS	NUMBER OF FISH
Disease	37	5,348
Spawning	7	710
Dissolved Oxygen	6	1,275
Toxic Pollutants	5	15,692
Aquatic Plants	5	651
Angling	5	539
Natural	4	400
Drawdown	3	2,536
Other (Alum)	1	16,908
Unknown	1	-

Fish abnormalities have been recorded at several locations in the state. Fin rot and liver tumors in fish from Boston Harbor are most likely due to the presence of carcinogens. Tumors have been observed on fish from the Sudbury River, Westborough Reservoir, Assabet River Reservoir (A-1 site), Flint Pond in Shrewsbury, Lake Chauncey, Westborough, Fort Meadow Reservoir, Marlborough and Quaboag Pond, East Brookfield. The cause of these abnormalities is unknown. It is speculated that they are genetically induced rather than pollution induced.

5.3 Sediment Contamination

National sediment criteria have not yet been established and there are no numerical sediment criteria in Massachusetts regulations. Previously, sediments were considered to be contaminated when the levels of contaminants in the sediments would result in a Category Three classification for dredge and fill material in accordance with the Massachusetts Dredging and Filling Regulations (314 CMR 9.00). A Sediment Quality Ranking system has since been developed for this assessment to provide a relative scale of sediment quality conditions. In this system freshwater sediment data are evaluated based on threshold levels found in Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (1993) by D. Persaud and R. Jaagumagi while marine sediment data are evaluated based on threshold levels found in NOAA's The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program (1990) by E.R. Long and L.G. Morgan. In addition, sediment toxicity testing, bioaccummulation factors and normalization to aluminum or iron are also considered. Table 5.3 contains a

list of those waterbodies in the state that are considered to have elevated levels of contaminants and the contaminants of concern.

5.4 Shellfish Growing Waters

The shellfish growing areas in Massachusetts divide into two distinct zones. North of Cape Cod the relatively large tidal range results in larger intertidal areas available for softshell clam harvest. South of Cape Cod there is a much smaller tidal range and no extensive "flats". However many species of shellfish have a subtidal as well as an intertidal distribution and are not normally found on flats. Although, shellfish remain relatively abundant in the waters of the Commonwealth, effort and harvest in areas such as the Northshore flats have been limited by pollution closures.

During the decade from 1970 to 1980 shellfish beds along the shores of major urban areas were closed due to risk of bacterial contamination. The total area of closure was relatively stable. However, during the period of 1980 to 1989 thousands of additional acres have been closed to shellfishing due to contamination. Furthermore, these areas included many suburban and rural areas along Cape Cod and the South Shore that were previously thought to be pristine.

In contrast, the area north of Cape Cod Bay has not experienced as rapid a rise in the rate of closures but the current conditions contains extensive closures. In this zone there are "Restricted Areas" where specially licensed diggers harvest moderately contaminated (with coliform bacteria) soft-shell clams for purification at the state-operated purification plant in Newburyport. All waters adjacent to Boston, Quincy Hull, Braintree, Weymouth, Hingham and Winthrop are closed or restricted. North of the Boston metropolitan area approximately 58% of the flats are closed.

Table 5.4 provides data from the Division of Marine Fisheries (DMF) regarding the assessment of shellfish growing areas based on water quality monitoring data. "Approved" areas have high water quality and support the shellfishing use. "Prohibited" areas are areas of poor water quality and do not support the shellfishing use. "Management closures" refer to areas of unknown water quality because they lack adequate monitoring. These areas are considered "not assessed" for the purposes of this report. Five other reporting categories are used that correspond to either support or partial support depending on the specific water quality classification of the waterbody (SA or SB). These categories account for only one percent of the total assessed waters.

Statewide 1,745,594 acres of shellfish growing waters were classified. Nearly 78% of these were approved areas. Nine percent were prohibited and another 12% were management closures. Since the shellfish program assesses over 2,700 square miles of coastal waters and DEP's marine program assess about 200 square miles, it can be assumed to better indicates the overall environmental conditions. Both programs are highly targeted though, and fall short of providing information that can be extrapolated to all estuarine and marine waters.

5.5 Bathing Area Closures

There is no compilation of monitoring data on beach closures on a state-wide basis. Municipal public health offices have authority and there is a lack of uniformity in monitoring practices.

TABLE 5.3
CONTAMINATED SEDIMENTS

	Waterbody	Cause
1.	Acushnet River	Metals, Priority Organics
2.	Assabet River	Metals, Priority Organics
3.	Blackstone River	Metals, Priority Organics
4.	Boston Harbor and Quincy Bay	Metals, Priority Organics
5.	Charles River	Metals, Oil and Grease
6.	Clark Cove	Metals, Priority Organics
7.	Connecticut River	Priority Organics (PCB's)
8.	Copicut River and Cornell Pond	Priority Organics (PCB's)
9.	Hocomonco Pond	Priority Organics (PAH's)
10.	Hoosic River	Priority Organics (PCB's)
11.	Housatonic River	Priority Organics (PCB's)
12.	Mill River (Blackstone River Basin)	Priority Organics (PCB's)
13.	Millers River	Priority Organics (PCB's)
14.	Muddy River	Priority Organics (PCB's)
15.	Mumford River	Metals, Priority Organics
16.	Mystic River/Alewife Brook	Metals, Priority Organics (PCB's,PAH's)
17.	Neponset River	Metals, Priority Organics
18.	New Bedford Harbor	Priority Organics (PCB's)
19.	North Shore:	
	- Inner Gloucester Harbor	Metals, Priority Organics (PAH's, PCB's)
	- Goldthwait Brook	Priority Organics (PAH's)
	- North River	Metals, Priority Organics (PAH's)
	- Salem Harbor	Metals
	- Salem Sound	Metals, Priority Organics (PAH's)
20.	Pentucket Pond	Arsenic
21.	Perryville Impoundment	Metals
21.	Sudbury River	Metals (Mercury)
22.	Ten Mile River	Metals (Lead)
23.	Sylvan Lake and Cochato River	Pesticides, Priority Organics (dioxin)
24.	Lake Winthrop	Priority Organics (Dioxin)

TABLE 5.4
SHELLFISH GROWING AREAS
ACRES (PERCENT)
AS OF JANUARY 1, 1996

AREA	APPROVED (SUPPORT)	VARIOUS (SUPPORT & PARTIAL) SUPPORT)	PROHIBITED (NONSUPPORT)	MANAGEMENT CLOSURES (NOT ASSESSED)	TOTAL
North Shore	20,175 (11%)	6,346 (4%)	103,099 (58%)	48,461 (27%)	178,080 (100%)
Boston Harbor	0 (0%)	2,240 (7%)	28,260 (92%)	230 (1%)	30,731 (100%)
Massachusetts Bay	50,552 (33%)	18 (0%)	8,192 (5%)	93,162 (61%)	151,924 (100%)
Cape Cod Bay	403,423 (98%)	3,175 (1%)	6,349 (2%)	0 (0%)	412,947 (100%)
Outer Cape Cod	129,684 (99%)	25 (0%)	5 (0%)	0 (0%)	129,714 (100%)
South Cape Cod	76,086 (55%)	2,237 (2%)	1,070 (1%)	57,931 (42%)	137,324 (100%)
Nantucket Sound	150,590 (100%)	0 (0%)	0 (0%)	0 (0%)	150,590 (100%)
Nantucket	156,999 (100%)	0 (0%)	506 (0%)	0 (0%)	157,505 (100%)
Martha's Vineyard	166,572 (95%)	484 (0%)	2,215 (1%)	6,997 (4%)	176,268 (100%)
Elizabeth Islands	81,417 (99%)	265 (0%)	162 (0%)	0 (0%)	81,844 (100%)
Buzzards Bay	116,498 (88%)	8,859 (7%)	6,812 (5%)	116 (0%)	132,285 (100%)
Mount Hope Bay	0 (0%)	0 (0%)	6,382 (100%)	0 (0%)	6,382 (100%)
Totals Statewide	**1,351,996 (78%)**	**23,649 (1%)**	**163,053 (9%)**	**206,897 (12%)**	**1,745,594 (100%)**

The Department of Public Health's bacteria standard is an instantaneous level of 1000 total coliform/100 ml and biweekly sampling. However some areas may use a level of 200 fecal coliform/100 ml and/or 104 enterococcus/100 ml. Usual monitoring frequencies are biweekly or weekly during the summer months.

The Natural Resources Defense Council (NRDC, July 1993) contacted several shoreline communities in Massachusetts including the MDC, all municipalities from Quincy to Plymouth, Lynn, Swampscott, the Barnstable County municipalities and Crane Beach in Ipswich. Their survey showed 59 closures/advisories in these areas for 1991, and 60 closing for 1992, where the count is compiled of a single beach being closed for a single day. There were no extended or permanent closings in Massachusetts.

The cleanup efforts in Boston Harbor have resulted in noticeable improvements to 20 beaches within the area. In 1991 the discharge of sewage sludge into the harbor was discontinued and in 1994 a new primary treatment plant was opened. Beaches that were closed for over a decade all now swimmable most days; the exception being after heavy rainfalls. Conditions are expected to continue to improve with the construction of secondary treatment and the clean-up of combined sewer overflows in the area.

5.6 Incidence of Waterborne Disease

The Massachusetts Center for Disease Control reported that there have been no outbreaks of disease that have been attributed to waterborne sources since 1988.

5.7 Public Water Supply (PWS)

5.7.1. Sources of Drinking Water Supplies

Approximately 55% of the population (3.3 million people) in Massachusetts are served by public surface water sources. Surface water is used as a water supply for all major urban areas in the Commonwealth. The Quabbin and Wachusett reservoirs which serve the greater Boston area account for about half of these supplies. Springfield, Worcester, New Bedford, Brockton and Fall River are also major users of surface water supply systems.

Groundwater provides a source of drinking water for over 45% of the population (2.7 million people) with 2.3 million people served by public drinking water systems. About 400,000 people have private wells as their source of drinking water. These wells are regulated by the Massachusetts Department of Public Health.

Although 55% of the population is served by surface water, 70% of the towns in Massachusetts rely solely or partially on groundwater.

Public water supplies are defined as water systems that provide piped water for human consumption to at least 25 individuals (or 15 service connections) at least 60 days of the year. Public supplies are divided into two main groups, Community and Non-Community with the following definitions:

- Community (COM) - primarily serving year round residents;
- Non-Community - serving water to non-residential customers which may include restaurants, factories, schools and hospitals. This group is further broken down into the following:

- Non-Transient Non-Community (NTNC) - serving at least 25 of the same persons over 6 months per year, such as at a school or office building; and

- Transient Non-Community (TNC) - those systems that do not meet the definition of a NTNC, including restaurants and motels.

Table 5.5 provides a summary of the public water systems in Massachusetts communities.

5.7.2. Water Quality Standards

The federal Safe Drinking Water Act (SDWA) Amendments of 1986 established a nationwide monitoring program for contaminants in drinking water. The Massachusetts DEP Division of Water Supply has primacy for implementing the provisions of the SDWA. The Massachusetts maximum contaminant level (MCLs) listed in 310 CMR 22.00 of the drinking water regulations constitute the Massachusetts Drinking Water Standards. The major categories of contaminants established in the SDWA standards are for bacteria, volatile organic compounds (VOCs), synthetic organic compounds (SOCs), inorganic compounds (IOCs) and radionuclides.

Massachusetts public water systems are currently monitored for up to 115 contaminants including VOCs, IOCs, SOCs, microbiological contaminants, turbidity, and radionuclides. All public drinking water supplies are monitored for finished water. Emergency and inactive sources are not required to monitor. Water quality data is reviewed by the Division of Water Supply (DWS) and the Office of Research and Standards (ORS). Additional review may be provided by toxicologists. ORS advises DWS on situations where a health risk may be present.

5.7.3. PWS Water Quality Assessment

In Massachusetts the number of groundwater sources outnumber surface supplies by more than 12 to 1. Because Massachusetts is a relatively industrialized state, the approximately twenty-five hundred groundwater supplies are subject to contamination from anthropogenic sources. According to the state's PWS Contamination List, groundwater sources account for 99% of all contaminated public water supplies.

As of September 1993, contamination had caused permanent or temporary closure of 206 public water sources in 85 communities. Only 2 of these contaminated sources were surface supplies. According to the 1993 contaminated source list for Massachusetts, 121 sources were contaminated by VOCs, 13 contaminated by inorganic compounds with 4 wells closed from nitrates, 5 contaminated by pesticides, 3 by bacteria, 41 contaminated by natural causes, and 23 contaminated by two or more different chemicals.

Bacteria. In 1994 the overwhelming majority of drinking water MCL violations (62) were due to coliform bacteria detections. Mitigation measures such as follow-up sampling, public notices, and treatment adjustment were implemented, restoring the sources to drinking water standards. Even though very few sources had to be permanently shut down because of bacteria, continual attention is prescribed for microbiological contaminants due to the possible acute effects of this type of contamination.

Volatile Organic Compounds. As of December of 1995, in addition to microbiological contaminants, the contaminants of utmost concern in Massachusetts drinking water are VOCs and nitrates. Since VOC contamination

TABLE 5.5

PUBLIC WATER SYSTEM INFORMATION

Number of communities in Massachusetts	351
27% rely on ground and surface water	94
42% rely only on groundwater	146
20% rely only on surface water	72
11% rely only on private wells	39
Number of communities relying solely on MWRA	32
Number of Public Water Supply (PWS) Systems in MA	1573
33% Community (COM) PWSs	519
54% Transient Non-community (TNC) PWSs	842
13% Non-Transient Non-Community (NTNC) PWSs	212
Number of PWS Sources (Active sources).....	2775

Class	Surface	Ground	Total
COM	209	1267	1476
TNC	3	1026	1029
NTNC	1	269	270
Total	**213**	**2562**	**2775**

Note: Emergency and Inactive sources not included.

is solely the result of anthropogenic sources, the presence of a VOC detect indicates a threat to drinking water quality. As the state has shallow wells in sand and gravel aquifers, is densely populated and supports extensive industry in close proximity to water supplies, VOC detects are ubiquitous throughout the Commonwealth with 261 sources having VOC detects. The most common VOC detects reported are:

Benzene	Toluene
Carbon Tetrachloride	Trichloroethylene (TCE)
Ethylbenzene	1,1,1-Trichloroethylene
Tetrachloroethylene (PCE)	Xylenes

One hundred five (105) of these sources were treated for volatile organic compounds, not including treatment from blending water.

Nitrates. As of December 1995, with approximately 70% of sources reporting as noted in the water quality data system, 61 sources (3.6%) are threatened by nitrates with levels of one half the MCL. Three of these sources reported detections over the MCL. Nitrate contamination is a significant public health concern for infants and other sensitive populations. In Massachusetts on-site septic systems and fertilizers constitute the major sources of contamination from nitrates. With increasing development pressure, cumulative nitrate-nitrogen loading is expected to be a contamination problem of increasing concern.

The Lead and Copper Rule. Lead in drinking water has caused much public concern although this is not a raw water source issue, but rather a distribution problem from lead and copper leaching from water pipes and fixtures. In Massachusetts the 25 cities and towns fully served by the Massachusetts Water Resource Authority (MWRA) public water supply system all failed the action level for lead of 15 ppb. Of the 14 PWS systems that serve more than 50,000 people, only 5 met the action level. Of the 194 systems serving between 3,300 and 50,000 people, 86 failed the lead action level and 38 failed the copper action level. Therefore, 124 medium size systems will have to implement corrosion control measures. Of the 456 systems serving fewer than 3,300 persons, 101 have failed either the lead or copper action level and will require corrosion control.

Sodium/Other Contaminants. Although Sodium does not have a MCL, DEP/ORS has established a recommended guideline of 28 mg/l. Sodium is a concern in Massachusetts due to the common highway practice of road salting as well as the storage of this salt. Sodium and chloride contamination have been contributors to the temporary or permanent closure of at least 7 wells as noted on the September 1993 Contamination List.

PWS Surface Water

Massachusetts has 213 active surface public drinking water sources. These surface supplies are predominantly drinking water reservoirs with fewer than a dozen direct river intakes. Surface water reservoir impoundments subject to water quality monitoring constitute 52,880 acres, with an additional 1,195 acres of surface sources classified as emergency water supplies. Table 5.6 contains a listing of sources which have been classified as public water supplies in the Massachusetts Surface Water Quality Standards while Table 5.7 lists sources classified as treated water supplies in these Standards. The Division of Water Supply has completed a GIS mapping project delineating watersheds for all surface water sources and the Metropolitan District Commission (MDC) has mapped on GIS the watersheds for sources under their jurisdiction.

Current statistics on the monitoring results of finished water for VOCs and Nitrates from 1993 through mid 1995 from the water quality tracking system (still under development) are detailed below. For purposes of this report, the following definitions for drinking water use apply:

> Full Support is defined by monitoring samples that do not exceed the MCL standard for a given contaminant.
>
> Threatened is defined as monitoring samples equal to or greater than one-half the MCL for a given contaminant.
>
> Non-Support is defined as those samples that exceed the MCL for a given contaminant. Annual average levels of contaminants were not considered.

Water quality data for 153 surface sources monitored for VOCs indicated that 150 sources (98%) are in full compliance (i.e., Full Support) with VOCs MCL. Sixteen (16) surface sources (10%) had VOC detects. Tables 5.6 and 5.7 indicate which sources were monitored for VOCs. All the surface sources listed which were monitored for VOCs are in Full Support of the VOC MCL except the Powwow River which is threatened and Graves Brook Lower Reservoir and the Merrimack River which are non-support.

With 82% of sources reporting, the water quality data for 175 surface sources monitored for nitrates indicate that 173 sources (99%) fully support drinking water use. Two surface sources reported levels defined as threatened with no surface source exceeding the MCL for nitrate. All surface sources listed in Tables 5.6 and 5.7 which were monitored for nitrates are in Full Support of the nitrate MCL except Nagog Pond and Accord Pond which are threatened. There are no surface sources exceeding the nitrate MCL.

TABLE 5.6

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
	Blackstone (51)			
51063	Holden Reservoir No. 1 (Upper Holden Reservoir)	Holden	x	x
51064	Holden Reservoir No. 2 (Lower Holden Reservoir)	Holden	x	x
51079	Kettle Brook Reservoir No. 1 (Reservoir No. 1)	Leicester	x	x
51080	Kettle Brook Reservoir No. 2 (Reservoir No. 2)	Leicester	x	x
51081	Kettle Brook Reservoir No. 3 (Reservoir No. 3)	Paxton	x	x
51082	Kettle Brook Reservoir No. 4 (Reservoir No. 4)	Paxton	x	x
51090	Lynde Brook Reservoir	Leicester	x	x
	Buzzards Bay (95)			
95175	Copicut Reservoir	Dartmouth/ Fall River	-	x
95127	Sand Pond	Wareham	x	x
	Cape Cod (96)			
--	Long Pond	Falmouth	x	x
	Charles (72)			
7239050	Charles River	Hopkinton/ Milford	x	x
72014	Cambridge Reservoir (Lower Hobbs Brook Reservoir)	Waltham/ Lincoln/ Lexington	x	x
72035	Echo Lake	Milford/ Hopkinton	x	x
72068	Louisa Lake	Milford	-	-
72105	Sandy Pond (Flint's Pond)	Lincoln	x	x
72114	Stony Brook Reservoir (Turtle Pond)	Waltham/ Weston	x	x
	Chicopee (36)			
36009	Barre Town Reservoir (Allen Hills Reservoir)	Barre	-	-

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Chicopee (36) Continued		
36015	Bickford Pond (Ropers Reservoir, Bickford Reservoir)	Hubbardston/ Princeton	x	x
36054	Doane Pond	North Brookfield	-	-
36072	Horse Pond (North Pond)	North Brookfield	x	x
36090	Mare Meadow Reservoir	Westminster/ Hubbardston	x	x
36115	Palmer Reservoir (Graves Brook Upper Reservoir, Palmer Upper Reservoir)	Palmer	x	x
36129	Quabbin Reservoir	Petersham/ Pelham/Ware/ Hardwick/ Shutesbury/ Belchertown/ New Salem	x	x
36138	Shaw Pond	Leicester	-	-
36145	Springfield Reservoir (Ludlow Reservoir)	Ludlow	-	-
	Unnamed Reservoir (Graves Brook Lower Reservoir, Palmer Lower Reservoir)	Palmer	x	x
		Concord (82)		
--	Wachusett Aqueduct (MWRA Open Canal)	Marlborough/ Southborough/ Northborough/ Westborough/ Berlin/Clinton	x	x
82047	Gates Pond	Berlin	x	x
82077	Millham Reservoir	Marlborough	x	x
82082	Nagog Pond	Littleton/ Acton	x	x
82046	Reservoir No. 3	Framingham	-	-
82106	Sudbury Reservoir	Marlborough/ Southborough	-	-
82114	Westboro Reservoir (Sandra Pond)	Westborough	x	x
82119	White Pond	Hudson/Stow	x	-
82121	Williams Lake	Marlborough	-	-

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Connecticut (34)		
34006	Atkins Reservoir (Atkins Pond)	Shutesbury	-	x
34028	Green Pond	Montague	-	-
34031	Hawley Reservoir	Pelham	-	x
34032	Hill Reservoir (New Amethyst Brook)	Pelham	-	x
34109	Lithia Springs Reservoir	South Hadley	-	-
34056	Mountain Street Reservoir	Williamsburg/ Hatfield/ Whately	x	x
34060	Northampton Reservoir (Northampton Reservoir [Old], West Whately Reservoir)	Whately	x	x
34070	Lake Pleasant	Montague	-	-
--	Reservoir (Mountain Brook Reservoir)	Westhampton	-	-
--	Reservoir (Running Gutter Brook Reservoir)	Hatfield	x	x
34076	Roberts Meadow Reservoir (Leeds Reservoir, Middle Reservoir)	Northampton	-	x
34089	Tighe Carmody Reservoir (Manhan Reservoir)	Southampton	-	x
34059	Unnamed Reservoir (Northampton Reservoir [New], Ryans Reservoir)	Whately	x	x
--	Unnamed Reservoir (Roaring Brook Reservoir)	Conway	x	x
34092	Unquomonk Reservoir	Williamsburg	-	-
34100	White Reservoir	Westhampton/ Southampton	-	-
34101	Whiting Street Reservoir	Holyoke	-	x
		Deerfield (33)		
33008	Greenfield Reservoir (Glen Brook Upper Reservoir)	Leyden	-	x
--	Lower Reservoir (Highland Springs)	Ashfield	x	x

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Deerfield (33) Continued		
33006	Unnamed Reservoir (Fox Brook Upper Reservoir)	Colrain	-	-
--	Unnamed Reservoir (Mountain Brook Reservoir, Mountain Spring Reservoir)	Colrain	-	-
--	Unnamed Reservoir (Phelps Brook Reservoir)	Monroe	x	x
	Upper Reservoir (Highland Springs)	Ashfield	x	x
		Farmington (31)		
--	Unnamed Reservoir (Sandisfield Road Reservoir and Spring)	Monterey	-	x
		Hoosic (11)		
1100525	Broad Brook	Williamstown	x	x
1101550	Thunder Brook	Cheshire		
11010	Mt. Williams Reservoir (Beaman Reservoir)	North Adams	x	x
11011	Notch Reservoir (Notch Brook Reservoir)	North Adams	x	x
--	Unnamed Reservoir (Kitchen Brook Reservoir)	Cheshire	-	x
11015	Williamstown Reservoir (Sherman Springs Reservoir)	Williamstown	-	-
		Housatonic (21)		
2105200	Ashley Brook	Washington	-	x
2103900	Karner Brook	Egremont/ Mt. Washington	-	x
21002	Anthony Pond (Anthony Brook Reservoir)	Dalton	-	-
21003	Ashley Lake (Ashley Brook Reservoir)	Washington	x	x
21004	Ashley Reservoir	Washington/ Dalton	-	-

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Housatonic (21) (Continued)		
21006	Lake Averic (Echo Lake, Mountain Mirror Lake)	Stockbridge	-	x
2100[illegible]	Basin Pond (Washington Mountain Brook Reservoir)	Lee	-	-
21010	Belmont Reservoir (Steam Sawmill Brook)	Hinsdale	-	x
21019	Cleveland Brook Reservoir (Cleveland Reservoir)	Hinsdale	x	x
21031	Egypt Reservoir (Egypt Brook Reservoir)	Dalton	x	x
21033	Farnham Reservoir	Washington	x	x
21059	Lenox Reservoirs (Lenox Reservoir, Lower Root Reservoir)	Lenox	x	x
21111	Lenox Reservoirs (Upper Lenox Reservoir, Upper Root Reservoir)	Lenox	x	x
21062	Long Pond	Great Barrington	-	x
21063	Lower Reservoir (Codding Brook Lower Reservoir, Vanetti Reservoir)	Lee	x	x
21064	Lower Sackett Reservoir	Dalton/ Hinsdale	-	-
21093	Sandwash Reservoir	Washington	-	x
21030	Unnamed Reservoir (East Mountain Reservoir)	Great Barrington	-	-
21112	Upper Reservoir (Leahey Reservoir, Codding Brook Upper Reservoir)	Lee	x	x
21113	Upper Sackett Reservoir (Sackett Reservoir)	Hinsdale	x	x
21119	Windsor Reservoir (Cady Brook Reservoir)	Hinsdale/ Windsor	x	x
		Ipswich (92)		
92030	Longham Reservoir	Wenham	x	x
92039	Middleton Pond (Forest Pond, Middleton Reservoir)	Middleton	x	x

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Ipswich (92) Continued		
92041	Mill Pond (Mill Pond Reservoir)	Burlington	x	-
92052	Putnamville Reservoir	Danvers	x	x
92065	Suntaug Lake	Lynnfield/ Peabody	x	x
92066	Swan Pond	North Reading	x	x
--	Unnamed Reservoir (Emerson Brook Reservoir)	Middleton/ No. Reading	x	x
92073	Wenham Lake	Wenham/Beverly	x	x
--	Winona Pond	Peabody	x	x
		Merrimack (84)		
8450950	Fish Brook	Andover	x	x
8450300	Powwow River	Amesbury	x	x
84002	Lake Attitash (Kimballs Pond)	Amesbury/ Merrimac	-	x
84006	Chadwick Pond (Little Pond)	Boxford/ Haverhill	-	-
84008	Lake Cochichewick	North Andover	x	x
84010	Crystal Lake (Creek Pond)	Haverhill	-	-
84022	Haggets Pond	Andover	x	x
84025	Hoveys Pond (Mitchell Pond, Johnson Pond)	Boxford	-	-
84027	Johnsons Pond	Boxford/ Groveland	-	-
84028	Kenoza Lake	Haverhill	x	x
84034	Lower Artichoke Reservoir	West Newbury	x	x
84041	Millvale Reservoir	Haverhill	-	-
84051	Lake Pentucket (Round Pond)	Haverhill	-	-
--	Unnamed Reservoir (Indian Hill Reservoir)	West Newbury	x	x
		Millers (35)		
35013	Cowee Pond (Marm Johns Pond, Cowee Reservoir)	Gardner	x	x

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Millers (35) Continued		
35014	Crystal Lake	Gardner	x	x
35023	Lake Ellis	Athol	-	-
36092	Lake Mattawa (North Pond Brook Reservoir)	Orange	-	-
35051	Newton Reservoir	Athol	x	x
35054	Paige Pond	Athol	-	-
35059	Perley Brook Reservoir	Gardner	x	x
35060	Phillipston Reservoir	Athol/ Phillipston	x	x
35090	Upper Naukeag Lake	Ashburnham	x	x
		Mount Hope Bay (Shore) (61)		
61004	North Watuppa Pond (North Watuppa Reservoir)	Fall River	-	x
		Mystic (71)		
71017	Fresh Pond (Fresh Pond Reservoir)	Cambridge	x	x
71029	Middle Reservoir (Winchester Waterworks)	Stoneham/ Medford	-	-
71033	North Reservoir	Stoneham/ Winchester	-	x
71038	South Reservoir (Winchester Waterworks)	Medford	-	x
		Nashua (81)		
81001	Ashby Reservoir	Ashby	-	-
81002	Asnebumskit Pond	Paxton	x	x
81032	Distributing Reservoir	Leominster	x	x
81038	Fall Brook Reservoir	Leominster	x	x
81039	Falulah Reservoir	Fitchburg	x	x
81043	Fitchburg Reservoir	Ashby	-	-
81049	Goodfellow Pond	Leominster	x	x
81055	Haynes Reservoir	Leominster	x	x
81062	Kendall Reservoir	Holden	x	x
81074	Lovell Reservoir	Fitchburg	x	x
81083	Meetinghouse Pond	Westminster	x	x

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Nashua (81) Continued		
81086	Morse Reservoir	Leominster	x	x
81089	Muschopauge Pond	Rutland	-	x
81092	Notown Reservoir (Leominster Reservoir)	Leominster	x	x
81096	Overlook Reservoir	Fitchburg	x	x
81102	Pine Hill Reservoir	Holden/Paxton/ Rutland	x	x
81108	Quinapoxet Reservoir	Holden/ Princeton	x	x
81119	Scott Reservoir	Fitchburg	x	x
81138	Simonds Pond	Leominster	x	x
81126	Snow Pond	Princeton	-	-
--	Unnamed Reservoir (Shattuck Reservoir)	Fitchburg	x	x
81146	Wachusett Lake	Westminster/ Princeton	x	x
81147	Wachusett Reservoir	Boylston/ Clinton/ Sterling/ West Boylston	x	x
		North Coastal (93)		
93001	Babson Reservoir	Gloucester	-	x
93004	Birch Pond (Birch Pond Reservoir)	Lynn/Saugus	x	x
93006	Breeds Pond (Breeds Reservoir)	Lynn	x	x
93011	Cape Pond	Rockport	x	x
93018	Crystal Lake	Wakefield/ Stoneham	x	x
93020	Dykes Pond (Dikes Meadow Reservoir, Dikes Pond)	Gloucester	x	x
93022	Fernwood Lake	Gloucester	-	-
--	Goose Cove Reservoir	Gloucester	-	-
93028	Gravelly Pond (Gravel Pond)	Hamilton	x	x
93031	Haskell Pond (Haskell Brook Reservoir)	Gloucester	x	x

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		North Coastal (93) Continued		
93032	Hawkes Pond	Saugus/ Lynnfield	x	x
--	Klondike Reservoir (Quarry Reservoir)	Gloucester	-	-
93061	Quarry Reservoir (Carlson's Quarry)	Rockport	x	x
93074	Spring Pond (Upper Tapley Brook Pond)	Peabody	x	x
93084	Walden Pond (Glen Lewis Pond)	Lynn/ Lynnfield/ Saugus	x	x
93085	Wallace Pond (Wallace Brook Reservoir, Wallace Reservoir)	Gloucester	x	x
		Parker (91)		
91002	Bull Brook Reservoir	Ipswich	-	-
91005	Dow Brook Reservoir	Ipswich	-	-
		Quinebaug (41)		
41012	Cohasse Brook Reservoir	Southbridge	x	x
41038	No. 3 Reservoir (Hatchet Reservoir No. 3)	Southbridge	x	x
41039	No. 4 Reservoir (Hatchet Reservoir No. 4)	Southbridge	x	x
41040	No. 5 Reservoir (Hatchet Reservoir No. 5)	Southbridge	x	x
42025	Henshaw Pond	Leicester	x	x
		South Coastal (94)		
94043	Furnace Pond	Pembroke	-	-
94053	Great Sandy Bottom Pond	Pembroke	x	x
94054	Great South Pond	Plymouth	x	x
--	Lily Pond	Cohasset	x	x
94087	Little South Pond (South Pond)	Plymouth	x	x

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		South Coastal (94) Continued		
94113	Old Oaken Bucket Pond (Herring Brook Pond)	Scituate	x	x
--	Unnamed Reservoir (Aaron River Reservoir)	Hingham	x	x
--	Unnamed Reservoir (Hingham Street Reservoir)	Rockland	x	x
		Taunton (62)		
62003	Assawompset Pond	Lakeville/ Middleborough	-	-
62023	Brockton Reservoir (Avon Reservoir, Salisbury Brook Reservoir)	Avon	x	x
62065	Elders Pond	Lakeville	-	-
62083	Great Quittacas Pond	Lakeville/ Middleborough/ Rochester	-	-
62107	Little Quittacas Pond	Lakeville/ Rochester	x	x
62108	Long Pond	Lakeville/ Freetown	-	-
62118	Monponsett Pond [East Basin]	Halifax	-	-
62119	Monponsett Pond [West Basin]	Halifax/ Hanson	-	-
62145	Pocksha Pond	Lakeville/ Middleborough	-	-
62174	Somerset Reservoir	Somerset	x	x
		Ten Mile (52)		
5233675	Sevenmile River	North Attleborough/ Attleboro	x	x
52029	Orrs Pond (City Pond, Upper Pond, Orrs Reservoir)	Attleboro	x	x

TABLE 5.6 (Continued)

PUBLIC SURFACE WATER SUPPLIES

CODE	USGS NAME	MUNICIPALITY	VOC MONITORING	NITRATE MONITORING
		Westfield (32)		
32002	Ashley Pond (Wrights Pond, Cedar Reservoir)	Holyoke	-	x
32004	Bearhole Reservoir (Prudys Pond)	West Springfield	x	x
32018	Cobble Mountain Reservoir	Blandford/ Granville/ Russell	x	x
32038	Granville Reservoir	Granville	x	x
32042	Horn Pond	Becket	x	x
32044	Huntington Reservoir (Cold Brook Reservoir)	Blandford	-	-
32046	Littleville Lake (Littleville Reservoir)	Chester/ Huntington	-	-
32049	Long Pond (Tucker Healy Pond, Lincoln Pond)	Blandford	x	x
32050	McLean Reservoir (Hugh McLean Reservoir, High Service Reservoir)	Holyoke	-	x
32062	Russell Reservoir	Russell	-	-
--	Unnamed Reservoir (Austin Brook Reservoir)	Chester	x	x
--	Unnamed Reservoir (Black Brook Reservoir)	Blandford	x	x
32078	Wright Pond	Holyoke	-	x
		Weymouth & Weir (74)		
42750	Accord Brook	Hingham	x	x
94002	Accord Pond	Rockland/ Norwell/ Hingham	x	x
74012	Great Pond	Braintree/ Randolph	x	x
--	Unnamed Reservoir (Richardi Reservoir)	Braintree	x	x
	Upper Reservoir	Braintree/ Randolph	-	-
74025	Whitmans Pond	Weymouth	x	x

TABLE 5.7

TREATED SURFACE WATER SUPPLIES

CODE	USGS NAME	VOC MONITORING	NITRATE MONITORING
8246500	Concord River	X	X
9253500	Ipswich River	X	X
8450125	Merrimack River	X	X
9355550	Saugus River	X	X
834900	Shawsheen River	-	-

PWS Ground Water

Massachusetts currently has 2,562 groundwater public water supply sources including 1,267 community sources serving 240 cities and towns. Due to increased water demand, groundwater source development in the Commonwealth is increasing while surface supply development trends show a slight decline.

Volatile Organic Compounds (VOCs): As Table 5.8 indicates, with 1115 ground sources reporting, 245 sources (22%) have VOC detects, 59 sources (5.3%) are threatened and 34 (3%) of these have had at least one MCL exceedance. Seventy-three (73) ground sources (6.5%) are treated for volatile organic compounds.

Nitrates: As Table 5.8 indicates, with 60% or 1535 ground sources reporting, 59 sources (3.8%) are threatened with levels one half the MCL or greater and 3 sources are Non-Support exceeding the MCL in at least one sample.

TABLE 5.8

STATEWIDE GROUNDWATER AQUIFER MONITORING DATA BASED ON FINISHED WATER FROM PUBLIC WATER SUPPLY WELLS

	NUMBER OF WELLS Indicator Groups	
	VOC	NO_3
Total number of wells used in the assessment	1115	1535
No detections of parameters above MDLs for VOCs and nitrate concentrations range from no detections to less than or equal to 5 mg/l	836	1473
Parameters are detected at concentrations exceeding the MDL but are less than or equal to the MCLs and/or nitrate ranges from >5 to $\leq$ 10 mg/l	245	59
Parameters are detected at concentrations exceeding the MCLs	34	3
Removed from service	55	4
Special Treatment	73	-

5.7.4 Water Supply Protection

In September 1995, Massachusetts became the first state in the country to receive EPA's endorsement of its Comprehensive Source Water Protection Program (CSWPP). Massachusetts demonstrated to EPA a comprehensive, integrated approach to water supply protection of both ground and surface water sources by describing the coordinating role of the Water Resources Commission and GIS mapping of priority resource areas.

The Source Protection Project which is a new 1995 DWS initiative focuses on developing a new state Source Water Protection Program to ensure integrated and consistent protection of surface and ground water drinking supplies. This goal is being accomplished through improvements to state drinking water regulations; incentive programs for developing and implementing local protection measures; and new technical assistance materials and workshops for public water suppliers.

In September 1995, Massachusetts also became the fifth state in the country to receive EPA endorsement of its Comprehensive State Ground Water Protection Plan (CSGWPP).

A first step in all water supply protection efforts is locating the recharge area of the source. DEP has established water supply protection areas as follows:

Zone I - that area closest to the well with a radius ranging from 100-400 feet. It must be owned or controlled by the water supplier.

Zone II - the recharge area to the well defined by hydrogeologic study.

Zone III- the remaining watershed.

For Surface Water Sources the following protection zones are used:

Zone A - 400 feet from the reservoir and 200 feet from tributaries.

Zone B - one half mile from the surface water source or the watershed boundary, whichever is less.

Zone C - the remaining watershed.

Since 1986, the Division of Water Supply has developed and implemented zone of contribution (Zone II) approval criteria for groundwater sources. As of January 1996, 222 approved Zone IIs have been delineated for 509 wells. One hundred thirteen (113) of the Zone IIs were delineated for new sources and 109 were delineated for existing sources.

For sources that do not have a hydrogeologically determined Zone II, DWS has established Interim Wellhead Protection Areas (IWPAs) based on a calculated radius and the approved pumping rate. For large size wells pumping 100,000 gallons per day (gpd) or greater, the IWPA radius is one half mile. All sources have some contributing recharge area mapped on GIS.

The Massachusetts approach to drinking water supply protection combines several strategies to provide a full suite of tools for ensuring protection. As discussed below, these include regulatory requirements, technical assistance, incentives and state programs designed to provide higher levels of protection to water supply protection areas.

Regulatory Requirements

Regulations which have been implemented include the following:

Wellhead Protection. Wellhead protection regulations became effective July 1990 for new sources designed to pump over 100,000 gpd [310 CMR 22.21(2)]. These regulations require municipalities to prohibit land uses which are potential sources of contamination within Zone IIs. Groundwater monitoring plans are also required as an early detection measure for some sources.

Water Management Act. The Water Management Act program has expanded its requirement of Zone II delineation and Wellhead Protection Requirements for all permitted sources as part of its 5-year source permit review process. This encompasses existing sources as well as new sources. Therefore, the Division of Water Supply anticipates that the number of approved Zone IIs and Wellhead Protection zoning and nonzoning controls to significantly increase over the next few years.

Watershed Protection Act of 1992 (Cohen Act). This act provides strong protection to the Quabbin, Ware and Wachusett Watersheds including 400 and 200 foot "no alteration" buffer zones around reservoirs and their tributaries, respectively.

Technical Assistance

DWS provides technical assistance through the Circuit Rider Program and other forums to all communities to help develop necessary land use controls at the local level. Many communities have independently developed Groundwater Protection Districts (174), or Watershed Protection Districts (81), or toxic and hazardous materials regulations (149).

Incentives

Financial incentives are available to eligible sources with protection through the SOC/IOC waivers programs and the surface water treatment rule filtration waivers.

VOC/SOC/IOC Waiver Program. With increasing monitoring requirements in the SDWA, water quality testing costs for public water suppliers have escalated. As a cost incentive, in addition to a protection benefit, DWS developed a monitoring waiver program for reduced testing of certain contaminants where it is determined that such contaminants are not a threat. In addition to having no detects for VOCs (volatile organic compounds), SOCs (synthetic organic compounds such as pesticides) and IOCs (inorganic chemicals such as metals) the waiver requires the public water supply system to have a watershed protection plan or a wellhead protection plan in place along with no threatening land uses in close proximity to the water supply. For the 1993 through 1995 compliance period, of the 1155 sources who applied, 632 sources were granted waivers for VOCs; 1054 sources were granted waivers for SOCs; and 1142 sources (128 surface and 1,014 groundwater) demonstrated having source protection in place.

Surface Water Treatment Rule (SWTR). The Surface Water Treatment Rule, an amendment to the Safe Drinking Water Act, states that unless systems meet criteria for avoiding filtration, all surface sources and groundwater sources under the influence of surface sources must be filtered by June 1993. Massachusetts has primacy for the SWTR and has developed criteria to assist towns in complying with this rule at minimal costs. However, in order to avoid the need and expense of developing a filtration plant, a number of

systems sought to develop alternate sources. To date, 17 systems have taken their surface water sources off-line while another 6 systems are planning to do so also. Twenty-five (25) systems are planning to filter and forty-eight (48) towns already have at least one water treatment filtration facility.

Two separate projects were developed under the SWTR. They include the Avoidance of Filtration for surface sources and Groundwater Under the Influence Exemptions from testing for groundwater sources.

Avoidance of Filtration Program. Under the Surface Water Treatment Rule surface water sources can avoid filtration by demonstrating that they would not be susceptible to microbiological contaminants. Thirteen (13) systems (out of 69 systems) applied and all met the criteria for avoiding filtration.

Another component of the Program involved enhanced source protection through a Water Resource Protection Plan (WRPP). The WRPPs were evaluated for nonpoint source pollution which included erosion, fertilizers and pesticides, road runoff, animal populations and other land use concerns. Systems without meeting filtration avoidance criteria will be required to build treatment plants or upgrade their existing plants to filter for turbidity and microbiological contaminants such as giardia lambia, viruses, bacteria, and legionella.

The Wachusett Reservoir serves 43 towns either fully or partially, and 25 water districts and water departments are currently using unfiltered water supplies and need to filter. The Commonwealth is offering a dual track approach managing these surface sources involving enhanced source protection to minimize the need to construct filtration plants. When appropriate, the Commonwealth emphasizes protection and pollution prevention as preferable to constructing filtration plants.

Groundwater Under the Influence (GWUI). Under this program groundwater sources can be exempt from filtration when the exemption criteria is met or when complete microscopic particulate analysis (MPA) testing is completed. More specific details of this program can be found under the Surface and Groundwater Interaction section below.

State Programs

State programs provide higher levels of protection to water supply protection areas.

Underground Injection Control (UIC) Program. This program proactively inspects floor drains in commercial and industrial facilities in a Zone II, Interim Wellhead Protection Area or surface water watershed that may be a threat to the water quality of a source. Since 1992 the UIC program has inspected 789 sites with 558 sites requiring some type of action to stabilize or have the floor drain removed. A total of 248 of these sites have been completely cleaned up as noted in the Ground Water Contamination Summary.

Other state programs that provide enhanced protection for water supply protection areas include: hazardous waste site cleanup, pesticides, Title 5 (septic systems), solid waste, wetlands, and others.

5.7.5 Surface and Groundwater Interaction

Groundwater Under the Influence (GWUI). Groundwater sources that either meet exemption criteria or complete microscopic particulate analysis (MPA) testing are exempt from filtration.

Exemptions for MPA testing are granted for sand and gravel groundwater sources that meet the following:

1) greater than 150 feet from a surface water feature
2) closer than 150 feet but in a confined aquifer, have a sanitary seal, and have had no coliform violations, and
3) closer than 150 feet but the top of the well screen is deeper than 50 feet, there is a sanitary seal, and the source has not had any coliform violations,

Exemptions for MPA testing are granted for bedrock groundwater sources that meet the following conditions:

1) have a sanitary seal, are deeper than 50 feet and are greater than 200 feet from a surface water feature,
2) have had no coliform violations.

Of the total 1364 GWUI sources, 907 have been granted exemptions by the exemption criteria and 255 have been granted exemptions by MPA analysis.

A total of 364 out of 397 community public water supplies have completed the process and received the waiver. The majority of the remaining systems are still undergoing the MPA sampling process.

An even distribution of waivers have been granted throughout the state. All sources which do not meet the exemption criteria must undertake MPA testing in order to evaluate the need for extensive wellhead protection and watershed control or filtration. Springs must automatically undertake the MPA sampling.

There are no known instances of contamination nor have there been any suspected instances of contamination due to ground water - surface water interactions. However, four groundwater sources in Massachusetts have been determined to be at high risk to contamination based on the results of microscopic particulate sampling and are determined as groundwater under the influence. These sources must filter or meet criteria to avoid filtration which includes demonstrating that protection criteria are met.

6.0 WETLANDS INFORMATION

6.1 Extent and Utility of Resource

Wetlands are recognized as one of our most valuable natural resources. Wetlands provide many important functions including: filtering pollutants and excess nutrients from our surface waters, removing contaminants from ground water, storing flood waters during rain and snow storms, and providing valuable habitat to many species of fish and wildlife.

Massachusetts wetlands vary from floodplains along rivers and streams, to beaches, dunes, and barrier beaches along the coast, to freshwater wetlands scattered throughout the state. Types of wetlands include the swamps, bogs, meadows, marshes, fens, beaches, and intertidal areas found along our coastline and throughout the inland areas of the Commonwealth.

Based on the 1975-1977 National Wetland Inventory (NWI) Maps, the U.S. Fish and Wildlife Service estimates twelve percent (approximately 590,000 acres) of the land area in Massachusetts are wetlands (Tiner, 1992). A breakdown of Massachusetts wetland acreage by specific wetland type is presented in Table 6.1. Major wetland types by county are listed in Table 6.2. The percentage of wetland area in various Massachusetts counties range from 4% in Franklin County to 36% in Nantucket County. Wetlands occupy 20 to 25% of the land areas in the Barnstable, Bristol, Essex, and Plymouth counties; from 10 to 15% of the land area in the counties of Dukes, Middlesex, Norfolk, Suffolk, and Worcester; and about 5% of the land mass in Hampden, Hampshire, and Berkshire counties. In total, about twenty percent of Massachusetts wetlands consist of marine and estuarine environments. Most of the remaining 80% of wetland areas consist of deciduous forested wetlands. About 14,000 acres (2.4%) consist of farmed cranberry bogs.

The preceding analysis of wetland types and acreage is based on aerial photographs collected by the U.S. Fish and Wildlife Service during 1975-1977. The NWI maps, however, are relatively small scale (1:75,000) and miss many wetlands smaller than one acre in size. The Division of Wetlands and Waterways through the Wetlands Conservancy Program is developing a larger scale (1:5,000), more detailed, and complete baseline of wetland resource information.

Over the next two years, the Wetlands Conservancy Program will continue to map and classify all wetlands in Massachusetts greater than or equal to 1/4 acre in size. To accomplish this task, the Conservancy Program is acquiring orthophotoquads at a 1:5,000 (1"=417') scale and color infrared aerial photographs (CIRs) at a 1:12,000 (1"=1,000') scale. The orthophotos are a very accurate multi-purpose basemap which have a positional accuracy of +/- 10.6 feet. Spring, leaves-off color infrared photographs in conjunction with photointerpretation and field verification will be used to delineate and classify wetlands 1/4 acre or larger.

This geographic information will be automated to create a new, statewide hydrography and wetland datalayer for the Massachusetts Geographic Information System (MassGIS). Orthophotos will be used to compile and automate highly accurate location data for Hazardous Waste (21E) sites and other DEP regulated objects. Inexpensive orthophoto wetland maps will be available for the general public, state agencies, or municipal conservation commissions. Digital Elevation Model data, a byproduct of orthophoto production, will also be made available through MassGIS for hydrologic modeling and surface contour mapping.

TABLE 6.1 **Massachusetts wetland acreage by type based on the U.S. Fish and Wildlife Service's National Wetlands Inventory. Wetlands are classified according to Cowardin and others (1979) (from Tiner, 1989).**

WETLAND TYPE	ACREAGE
Marine Wetlands	
Beach/Bar	23,381
Intertidal Flat	14,303
Rocky Shore and Aquatic Bed	1,049
TOTAL	**38,733**
Estuarine Wetlands	
Emergent (includes 71 acres of Scrub-Shrub)	47,704
Intertidal Flat	29,227
Beach/Bar	2,214
Other Estuarine	122
TOTAL	**79,267**
Palustrine Wetlands	
Open Water and Aquatic Bed (Pond)	23,038
Emergent	24,240
Deciduous Forested	299,497
Evergreen Forested	27,415
Dead Forested (mostly beaver-modified)	2,964
Deciduous Scrub-Shrub	71,928
Evergreen Scrub-Shrub	2,725
Farmed (cranberry bog)	14,194
Other Palustrine	122
TOTAL	**466,123**
Lacustrine Wetlands	
Aquatic Bed	2,501
Emergent	1,291
Other	529
TOTAL	**4,321**
Riverine Wetlands	42
STATE TOTAL	**588,486 ACRES**

TABLE 6.2 County wetland acreage summaries for Massachusetts based on NWI mapping (from Tiner, 1989).

COUNTY	MARINE WETLANDS (acres)	ESTUARINE WETLANDS (acres)	PALUSTRINE WETLANDS (acres)	LACUSTRINE WETLANDS (acres)	RIVERINE WETLANDS (acres)	TOTAL WETLANDS (acres)
Barnstable	20,416	23,113	15,066	50	-	58,645
Berkshire	-	-	29,259	631	2	29,892
Bristol	1,431	6,665	62,079	301	-	70,476
Dukes	1,389	2,012	2,949	51	-	6,401
Essex	3,960	22,762	41,930	106	-	68,758
Franklin	-	-	16,021	452	30	16,503
Hampden	-	-	20,913	91	-	21,004
Hampshire	-	-	17,290	289	10	17,589
Middlesex	-	-	58,004	349	-	58,353
Nantucket	6,625	1,093	3,068	-	-	10,786
Norfolk	54	3,470	29,554	101	-	33,179
Plymouth	3,702	17,615	75,749	413	-	97,479
Suffolk	1,156	2,537	579	-	-	4,272
Worcester	-	-	93,662	1,489	-	95,149
TOTALS	**38,773**	**79,267**	**466,123**	**4,321**	**42**	**588,486**

Since 1990 the Wetlands Conservancy Program has acquired CIRs for approximately 55% of the state including: Metro/Suburban Boston, Buzzards Bay (West Shore), the MDC watersheds for the Quabbin, Wachusett and Sudbury Reservoirs, the North Shore and Merrimack Valley, Cape Cod and the Islands, and complete coverage of Plymouth County and Bristol County in Southeastern Massachusetts. Orthophotoquads are available for Metro Boston, Buzzards Bay area, and the MDC watersheds. In addition to these areas, both CIRs and Orthophotoquads have been acquired for the Fort Devens complex centered in Ayer, Massachusetts, as part of the hazardous waste cleanup associated with the base transfer process.

For the areas with existing orthophoto and CIR coverage, wetland resources have been delineated, classified, and automated as a GIS database (wetlands delineated, classified and digitized). Approximately 14% of the state is included in this new GIS wetland datalayer. Preliminary estimates of wetland acreage by wetland type is presented in Table 6.3. Over 81% of the mapped area is upland with approximately 14% classified as wetland or open water. These wetland statistics will be invaluable to update Massachusetts wetland resource inventories and in the EOEA Watershed Assessment approach. This database in conjunction with the Division's WETINFO permit tracking system will be utilized to quantify wetland losses. Continued state support of the Wetlands Conservancy statewide mapping project, however, is essential to the long term effectiveness of Massachusetts' efforts to identify and protect wetland resources.

Submerged Rooted Vascular Plant Inventory

The Wetlands Conservancy Program has commenced a three year program to accurately inventory the state's submerged rooted vascular plant (SRV) resources. The goal of this program is to map the SRV along the entire Massachusetts Coastline. The maps that are generated will provide a baseline of the SRV resources along the Massachusetts coastline and will provide valuable resource abundance and distribution information for trend analysis, identification of critical habitat areas, and permit review. This project is being conducted in cooperation with the MA Office of Coastal Zone Management and the National Marine Fisheries Service.

The project consists of acquisition and interpretation of aerial photography at the 1:20,000 scale. In contrast to other types of photointerpretation, extensive fieldwork and underwater survey work is required to accurately delineate and classify the submerged SRV and algae resource areas. All fieldwork and photointerpretation is conducted in accordance with methodologies developed through the Coastal Change Analysis Program (C-CAP), a component of the National Oceanic and Atmospheric Administration, Coastal Ocean Program.

By the end of 1995, the project has completed mapping for approximately two thirds of the state's shoreline. The SRV data is available on analogue hard copy photomaps. Comprehensive sets of these maps have been distributed to all levels of federal, state and local regulatory and resource management agencies. As a digital base map for the coastline is developed, the SRV data will be incorporated.

The areas which have been completed by the WCP SRV Mapping Program include: Nantucket, Martha's Vineyard, Cape Cod, and South Shore (Cape Cod Canal to Hull). The areas which are projected to be completed in 1996 are: Boston Harbor, North Shore (Boston to NH), and Buzzard's Bay.

TABLE 6.3

PRELIMINARY WETLAND ACREAGE
WETLANDS CONSERVANCY PROGRAM

WETLAND TYPE	WACHUSETT/WARE	BOSTON	QUABBIN	TOTAL ACRES
Shrub Swamp	3,366	511	1,445	5,322
Hardwood Swamp	10,070	3,594	1,896	15,560
Marsh, Wet Meadow	1,628	1,438	1,151	4,217
Open Water	10,873	3,577	23,641	38,091
Deep Marsh	1,756	414	1,488	3,658
Conifer Swamp	2,440	32	1,183	3,655
Mixed Swamp	4,050	178	1,186	5,414
Bog	524	6	220	750
Beach	--	811	--	811
Rocky Intertidal Shore	--	173	--	173
Coastal Bank	--	299	--	299
Tidal Flat	--	636	--	636
Salt Marsh	--	1,319	--	1,319
Dune	--	29	--	29
Barrier Beach	--	757	--	757
Totals	**34,707**	**13,774**	**32,210**	**80,691**

The WCP will continue its cooperative relationship with the MA Office of Coastal Zone Management and National Marine Fisheries Service throughout the duration of this statewide SRV data acquisition. At the completion of the 1996 season, Massachusetts will become the first state to have completed an accurate SRV inventory of this comprehensive nature.

6.2 Wetlands Monitoring

The Division of Wetlands and Waterways does not have a statewide wetlands monitoring program in place at this time. Occasionally, Orders of Conditions, Superseding Orders of Conditions, a Variance to the Wetlands Protection Act, or a 401 Water Quality Certificate may require project proponents to monitor specific aspects of a project (e.g. wetland plant coverage, water quality data) and submit this information to the Division or local conservation commission. The Division anticipates additional information on both wetland condition and restoration potential will be collected by the Wetland Restoration and Banking Program and the Office of Watershed Management basin assessment teams.

6.3 Impacts - Cumulative Loss Estimates

The U.S. Environmental Protection Agency estimates approximately 54% of the wetland area in the United States has been destroyed since the country was first colonized by European settlers. Total loss of Massachusetts wetland acreage since colonial times is estimated to be at least twenty-eight percent (28%) (Dahl, 1990). In Massachusetts, wetlands are frequently proposed to be altered for residential/commercial developments, highway expansions, roadway crossings, farming activities, mosquito control, construction or maintenance of public facilities, and recreational uses. The U.S. Fish and Wildlife Service determined that between 1977 and 1986 over 1300 acres of vegetated wetlands in Southeastern Massachusetts and another 164 acres of vegetated wetlands from Plum Island to Scituate were destroyed or converted to other uses (Tiner and Zinni, 1988; Foulis and Tiner, 1992).

A review of wetland permits conducted by DEP in the Northeast region indicated slightly more Bordering Vegetated Wetlands were replicated than filled. These replicated BVW areas, however, do not provide the full complement of wetland functions and the failure rate may exceed 30% in Massachusetts (ACOE 1989). Additionally the DEP Northeast Regional study focused on permitted activities and does not provide an accurate estimate of wetland losses through illegal or unpermitted activities. Increased compliance and enforcement efforts by DEP and local conservation commissions are needed to reduce unpermitted losses.

Wetland Restoration and Banking Program

The Wetlands Restoration & Banking Program was conceived on the premise that Massachusetts can benefit more by treating wetlands as components of aquatic systems within watersheds and coastal ecosystems than as isolated landscape features. The Wetlands Restoration & Banking Program has two components: (1) proactive wetlands restoration (not required by a permit) and (2) wetland mitigation banking both of which are to be implemented based on watershed considerations.

Proactive Wetlands Restoration: The wetlands restoration initiative is intended to be a proactive program restoring wetlands simply to return lost area and functions of wetland ecosystems and lost wetland benefits to society.

Proactive wetlands restoration projects are initiated by sponsors who want to bring back wetlands to help solve community water quality or local flooding

problems or to restore lost wildlife or fisheries habitat. These projects will increase wetland acreage in the Commonwealth and improve the functions of degraded wetlands. Initiation of these projects will not be dependent on any losses or degradations that result from activities subject to state regulations (i.e., compensatory mitigation for permitted projects or unauthorized activities). Therefore, proactive restoration contributes to achieving the policy goal of a net gain in wetlands.

WRBP plans to develop a statewide network of restoration sites. Each restoration project will be supported by a project sponsor and a volunteer team. Each site will have an active education and outreach component. Baseline and monitoring data will be gathered and entered into a statewide wetlands restoration data base. Due to be implemented in 1996, this system will inform and improve wetlands restoration efforts.

WRBP's proactive wetlands restoration effort is being integrated with the other watershed management initiatives within the state. For example, WRBP is working cooperatively with the Office of Watershed Management to incorporate elements of watershed wetlands restoration plans into overall basin management plans.

Wetlands Mitigation Banking: According to an Army Corps of Engineers report issued in 1989, wetlands replication projects in Massachusetts experienced a 36 percent failure rate. The WRBP Advisory Committee (AC), a broad-based group representing diverse interests, was appointed in May 1994 to explore the question of whether wetlands mitigation banking can improve wetlands mitigation success in Massachusetts and contribute to the state's goal of "no net loss of wetlands".

A wetlands mitigation bank is a site where wetlands are restored and/or created expressly for the purpose of providing compensatory mitigation in advance of authorized, unavoidable impacts to similar resources. Because banking mitigates for numerous individual wetland conversions, compensation sites are likely to be larger and more likely to be functionally viable - hydrologically and biologically. In addition, banked compensation wetlands can achieve functional success in advance of the wetland impacts for which they are to mitigate, as opposed to the current practice of after-the-fact mitigation; and they can be continuously monitored and managed to assure the continuing production of the replaced wetland functions.

On August 22, 1995, the AC issued its report regarding wetlands mitigation banking. Recommendations included implementing several pilot wetlands banks in order to further explore their potential and investigating other methods of improving mitigation success (for example, more detailed technical requirements and better training for consultants and regulators). The AC has recommended that preference be given to wetlands restoration over wetlands creation. Restoration sites have supported or still do support wetlands, improving the chance of successful mitigation. The AC recommended that pilot bank sites be chosen from potential wetlands restoration sites identified in Watershed Wetlands Restoration Plans so they can contribute to addressing cumulative as well as site-specific wetland impacts. Secretary Coxe has accepted the recommendations and implementation already is underway.

6.4 Massachusetts Wetlands Protection Legislation

Due to the loss of thousands of valuable acres of wetlands in Massachusetts over past decades, the need to protect the remaining wetland resource areas in the Commonwealth is paramount. Massachusetts led the nation in wetlands protection by passing the first-ever statute in 1963 for coastal wetlands

protection. A statute for inland wetlands protection was passed in 1965. In 1972 the two laws were consolidated to form the State's Wetlands Protection Act. The Act gives initial permit review authority to local conservation commissions, volunteer boards of from 3 to 7 appointed members. Most of the 351 cities and towns in the Commonwealth have a conservation commission. If a conservation commission is not established, then the local Board of Selectmen or the Mayor performs this function. Not every community, however, has a conservation commission or implements the Wetlands Protection Act through municipal officials.

The Wetlands Protection Act requires conservation commissions to review and regulate activities which propose to remove, fill, dredge, or alter wetlands. Permits may be granted or denied based on impacts to the eight interests for which wetlands are protected: public and private water supply, groundwater supply, prevention of pollution, storm damage prevention, prevention of flooding, protection of fisheries, protection of land containing shellfish, and wildlife habitat. Although wetlands are also considered to have aesthetic and recreational values, the current state wetland regulations do not allow these attributes to be considered in the regulating of activities in and around wetlands resource areas. Some local wetland bylaws, however, include both aesthetic and recreational values.

The Massachusetts regulations are among the most strict wetlands protection laws in the country. With passage of the coastal wetlands regulations, the alteration of valuable saltmarsh areas has been all but eliminated. Since passage of revised inland wetland regulations in 1983, the alteration of vegetated wetlands along inland rivers and streams has been greatly reduced. For almost all projects that come before conservation commissions, these inland wetland regulations prohibit any alteration of wetlands greater than 5,000 square feet and require 1:1 replication of any wetland destroyed. For certain classes of projects, however, such as land in agricultural use, forestry, existing roadways, and new public utilities, conservation commissions may allow greater than 5,000 square feet alterations on a case by case basis. Wetland replication may or may not be required for these projects. Additionally, some activities such as bridge repair projects, maintenance of land in agricultural use, mosquito control and maintenance of existing utilities are exempt from the Wetlands Protection Act.

Even with the strict regulations that have been developed over the years, there is a need to do more to protect the Commonwealth's wetlands resources. To meet this challenge, the DEP's Division of Wetlands and Waterways has taken steps to streamline the wetland permitting process by incorporating the 401 Water Quality Certification process into Wetlands Protection permitting, developed educational programs to provide training and technical assistance to conservation commissions; revised Agriculture provisions of the Wetlands Protection regulations and developed guidance for both forestry and agriculture activities; and worked with the EPA, NRCS and ACOE to change the way Bordering Vegetated Wetlands are delineated under the State WPA in order to bring the state and federal delineation methodologies closer together. Additionally, since 1992 the DEP has made many changes to the Wetlands Protection Act Regulations to provide further protection to wetland resource areas and clarify regulatory processes (Table 6.4).

6.5 Trends in Wetland Impacts

From 1988 to 1995 a total of 53,270 permit applications (Notices of Intent) to work in or near wetlands resource areas were submitted to conservation commissions statewide (Table 6.5). After declining from 8,619 NOIs in 1988 to 5,358 in 1991, the number of NOIs filed each year has remained in the 6,200 to

TABLE 6.4
WETLANDS PROTECTION ACT CHANGES 1992 - 1995

REVISION DESCRIPTION	REGULATION CITATION	EFFECTIVE DATA
Definition of Pond	310 CMR 10.04 Definition	November 20, 1992
Rare Wildlife species habitat identification procedures	310 CMR 10.37,10.59	November 20, 1992
Limitations on work in BVWs located in ACECs	310 CMR 10.55	April 23, 1993
Clarification of exempt and non-exempt agricultural projects	310 CMR 10.04 Definition 310 CMR 10.06(6) Agricultural Emergencies 310 CMR 10.53(3)	May 21, 1993
Reduction in fees for Variance applications involving alleged "taking" of property without Compensation	310 CMR 10.03	June 18, 1993
Addition of five new limited projects addressing: dam safety, public groundwater supply exploration & development, airport tree clearing, landfill closure, and oil and/or hazardous material release cleanups	310 CMR 10.53(3) 310 CMR 10.24(7)	January 1, 1994
Clarification of emergency certification for all projects; additional emergency certification rules for 21E response actions	310 CMR 10.06	January 1, 1994
401 Water Quality Certification Regulations 401 Certification process incorporated into WPA process	310 CMR 9.00	March 15, 1994
Definition of Bordering Vegetated Wetlands which includes use of soils, recommends specific methods to determine BVW line	310 CMR 10.55(2)	June 1, 1994
Clarification of exempt and non-exempt forestry projects	310 CMR 10.04 Definition 310 CMR 10.53(3)(r+s)	November 15, 1995

Table 6.5 **Notices of Intent submitted to local conservation commissions by region during 1988 to 1995.**

	YEAR							
REGION	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
Southeast	3,184	2,987	2,437	2,219	2,979	2,639	2,481	2,534
Northeast	2,613	1,894	1,475	1,473	1,800	1,692	1,842	2,067
Central	1,916	1,883	1,182	1,077	1,278	1,396	1,463	1,537
Western	906	855	739	589	549	535	444	605
Totals	**8,619**	**7,619**	**5,833**	**5,358**	**6,606**	**6,262**	**6,230**	**6,743**

6,700 range since 1992. The pressure to develop in wetland areas and buffer zones remains high. During the last two years, the highest levels of NOI's filed (39%) were observed in the Southeast-Cape Cod Region of the State. Projects proposed in the metropolitan Boston and Northeast section of Massachusetts accounted for 30% while Central and Western Massachusetts received the final 31% of project applications.

The Division's enforcement efforts improved from 74 Notice's of Noncompliance or Enforcement Orders in 1993 to 114 enforcement actions in 1995. Unreported or unpermitted wetland alterations continue to present a problem to the Division. Increased enforcement and compliance efforts, however, are hampered by a continued lack of resources both at the municipal and state levels.

6.6 Wetland Protection Program Informational Needs

In order to more accurately determine trends in wetland resources, both in relative health and total acreage by type, monitor enforcement and compliance efforts, and track cumulative wetland loss, the Division must continue to gather up-to-date wetland maps and wetland monitoring data. Additional funds and tools, however, will be required to assess the relative health of wetlands on a priority watershed basis.

The Division's information needs include:

- complete wetland and Submerged Rooted Vascular plant mapping statewide;
- assessment of how specific activities within the buffer zone impact wetlands and identification of BMPs to protect wetlands, including information or appropriate setback distances and/or no build zones;
- information on the health of wetlands, and identification of potential restoration projects on watershed/subwatershed basis; and
- assessment of NPS impacts to wetlands and identification of mitigative measures to minimize these impacts.

6.7 Coordination with other State and Federal Agencies

The Division of Wetlands and Waterways has dedicated considerable effort to coordinate its policies and goals with other Divisions within DEP, other Massachusetts agencies, and federal agencies including: The U.S. Army Corps of Engineers (ACOE), U.S. Environmental Protection Agency (EPA), Natural Resources Conservation Service (NRCS), DEP Office of Watershed Management (OWM), the Massachusetts Coastal Zone Management program (CZM), Wetland Restoration and Banking Program (WRBP), Department of Food & Agriculture (DFA), and Department of Environmental Management (DEM). New BRP initiatives since 1993 include:

- promulgation of 401 Water Quality Certification regulations and Programmatic General Permit (PGP);
- revision of Wetlands Protection Regulations BVW definition;
- stormwater BMP guidance; and
- revision of the Wetlands Protection Regulations to clarify agriculture exemptions including forest cutting practices and aquaculture.

Each of these topics is discussed briefly below.

6.8 401 Water Quality Certification and PGP

Programmatic General Permit (PGP)

The Division of Wetlands and Waterways (DWW) worked closely with DWPC, CZM and the ACOE in reviewing the proposed revisions to the 404 Nationwide Permits and establishing a Massachusetts programmatic general permit (PGP) for dredge and

fill activities under Section 404 of the Federal Clean Water Act. The Massachusetts PGP has been drafted to provide federal authorization (without the need for individual permit application) for specified projects with minimal impacts to wetlands and waterways, using thresholds consistent with the Massachusetts Wetlands Protection Act, the 401 Water Quality Certification Program, and the Massachusetts Environmental Policy Act.

The PGP which is based on impacts to wetlands rather than types of activities has replaced the Corps' system of nationwide permits and other general permits. Projects filling less than 5,000 square feet (sq. ft.) can proceed without review by federal agencies. Projects filling between 5,000 sq. ft. and one acre will be screened by the federal agencies. Projects involving the filling of more than one acre must receive an individual permit from the Corps. The PGP increases wetlands protection because the new 5,000 sq. ft. threshold for screening by federal resource agencies is far lower than the prior thresholds for nationwide permits, allowing these agencies more opportunities to review projects and to identify avoidable wetlands losses. DEP conditioned the PGP to require compliance with the Wetlands Protection Act, Chapter 91 Waterways licensing, and the 401 Water Quality Certification Program, as applicable. Thus projects of all sizes will receive some level of review at the local, state, and/or federal levels.

An Interim PGP was issued in August 1993 while DEP drafted new 401 regulations. A final PGP was issued in Spring 1994 to coincide with promulgation of the 401 regulations.

401 Water Quality Certification

The Division of Wetlands and Waterways incorporated the 401 Water Quality Certification process into the Wetlands Protection Program and issued new regulations for the 401 Water Quality Certification process in 1994. The 401 Certification program provides additional protection to wetland resources in a number of ways. For instance, no filling of Outstanding Resource Waters (ORWs) is allowed; an Alternative Analysis is required for any filling greater than 5,000 square feet of federal wetlands; no direct discharge of untreated surface water is permitted; all discharges must be pretreated by an appropriate practice such as retention ponds, detention ponds, diffusers, or oil and grease traps. Additional protection of resource areas is also provided by erosion control conditions placed on construction activities.

The Wetlands Protection Act provides for a number of limited projects including roadway crossings of wetlands into areas without another means of access. Replication of filled wetlands is at the discretion of the conservation commission or the Department in such cases and sometimes these crossings are allowed to fill wetland areas without replication being required. The 401 Water Quality Certification process, however, can require wetland replication for these projects. Additional protection of wetland resources can be provided by 401 program when the time limits for project appeals specified in the Wetlands Protection Act expire without an appeal filed by either the conservation commission or the Department. These projects, if they involve significant wetland alterations or further degradation of water quality, can be denied a Water Quality Certificate.

In the Massachusetts Surface Water Quality Standards all wetlands are classified as "waters of the commonwealth". DWW worked with OWM to designate all wetlands as "High Quality Waters", or as "Outstanding Resource Waters" if they are located in critical areas such as water supply watersheds or specific sections of Areas of Critical Environmental Concern. In addition to wetlands, DWW worked with OWM to identify other Outstanding Resource Waters such as tributaries to Public Water Supplies. Certified vernal pools which provide

important wildlife habitat are separately identified and designated as Outstanding Resource Waters (Mass. DEP 1995).

Bordering Vegetated Wetland Regulation Revisions

Bordering Vegetated Wetlands include inland marshes, swamps, bogs and wet meadows. Under Massachusetts Wetland Protection regulations, the delineation of BVWs has in the past relied primarily on wetland vegetation as a boundary indicator. Federal regulations, however, use three criteria, vegetation, soils and hydrology to determine the BVW boundary. Starting in 1992, DEP has enacted several measures to consolidate programs and streamline the local, state, and federal wetland permitting process. Part of this initiative was the transfer of the 401 Water Quality Certification Program to the Wetland Protection Program. Since jurisdictional areas under 401 are determined using the federal three- criteria approach, while the state program used primarily wetland vegetation, reducing discrepancies between state and federal BVW boundaries was key to the streamlining objective.

The revised BVW regulations incorporates indicators of wetland hydrology (groundwater elevation, surface water, and hydric soils) along with vegetation to determine wetland boundaries. The hydrologic indicators are especially important for disturbed sites which can be difficult to delineate solely on vegetation. Changes to the BVW regulations (310 CMR 10.55) became effective June 30, 1995. DEP, with assistance from federal agencies, has embarked on an aggressive training program to provide Conservation Commission and other municipal officials with the necessary tools and training to delineate wetlands using the new approach.

Storm Water Guidance

The Department of Environmental Protection and the Office of Coastal Zone Management with assistance from an advisory committee have been discussing new ways to streamline the existing stormwater permitting process and to improve water quality threatened by discharges of stormwater. Advisory committee members represent a broad spectrum of interest groups including the National Association of Industrial and Office Properties (NAIOP), Homebuilders, Mass Audubon, Massachusetts Association of Conservation Commissions (MACC), and the Boston Bar Association. DEP and CZM proposed the implementation of cost-effective performance standards through existing, widely accepted regulatory programs.

Both the technical and policy aspects of this proposal are being explored by the Advisory Committee including: 1) the size "storm event" that should be used for water quality analysis; 2) design of redevelopment (on previously developed land) to meet the stormwater standards where practicable; and, 3) maintenance of peak discharge rates to avoid flooding and storm damage impacts. Policy and regulatory issues under discussion include: 1) standards to be incorporated into reviews of new development or redevelopment by conservation commissions. Most new projects generating stormwater discharges are already subject to the Wetlands Protection Act; 2) addressing existing serious impairments of water quality from stormwater ("hot spots") by education and enforcement through the watershed approach; 3) development of guidance based on existing authority (no new regulations are planned at this time); 4) implementation of the stormwater performance standards primarily through wetlands permits (no new permitting system is proposed). DEP could use existing storm water permitting authority to designate large projects for NPDES-type discharge permits on a case-by-case basis and in close consultation with EPA (Massachusetts is not an NPDES-delegated state).

Development of Best Management Practices (BMPs) and a "user-friendly" supporting manual that will assist both local officials and design engineers in implementing the proposed performance standards is essential to the success of this approach. Training workshops are also critical to successful implementation.

Revisions to Agriculture exemption provisions

In 1993, the DEP revised the Wetlands Protection Act regulations to clarify the agricultural exemptions contained in the 310 CMR 10.04 definition of agriculture. A three year "sunset" provision was included to ensure that DEP had sufficient time to review the revisions and determine if they were effective. Since 1993, DEP, in cooperation with DFA has produced a Guidance Document on Farming in Wetland Resource Areas and conducted a series of workshops statewide to educate conservation commissions and farmers on the revised definitions. DEP and DFA also co-chaired a committee from the agricultural and environmental communities to monitor the implementation of the revisions and their effects on both agriculture and wetlands.

In December 1995, this group concluded the revised regulations have done a good job in clarifying the agriculture exemptions, and recommended removal of the sunset provision without any other additional changes to the agricultural exemption provision. Continuation of workshops which focus on farming in wetlands and updating the guidance document with additional cases histories to illustrate jurisdictional interpretations were strongly recommended.

Public Hearings on the proposal to reauthorize the current provisions of the Wetlands Protection Act pertaining to agriculture and remove the sunset provision were conducted in February 1996. Based on the public comments received and recommendations of the Farmland Advisory Committee, DEP recommended the agricultural regulation with the Secretary of State to delete the sunset provision.

Forest Cutting Practices

As part of DEP's efforts to clarify agricultural exemptions to the Wetlands Protection Act regulations, the DEP adopted new wetland regulations for forestry activities (310 CMR 10.04 Definitions) effective November 1995. These revisions were closely coordinated with the Department of Environmental Management's (DEM) changes to its Forest Cutting Practices Act (FCPA) regulations (304 CMR 11.00) effective January 1996. This coordinated approach extended to a combined set of DEP/DEM Public Hearings, workshops, and issuance of guidance documents during 1995. Additional Workshops are planned for Spring 1996.

DEM's amendments improve protection for surface waters and wetlands during forest harvesting operations by emphasizing use of Best Management Practices (BMPs) for erosion and sedimentation control and by providing clear standards for logging practices. DEM has summarized these Forest Cutting BMPs in a new easy-to-use manual which has been widely distributed to conservation commissions, foresters, environmentalists and municipal officials.

Status of FY 92 AND FY 93 104(b)(3) Projects

The Division of Wetlands and Waterways has received federal funds through section 104(b)(3) of the Clean Water Act to conduct nine projects:

- develop a Two-tier approach to functional assessment of wetlands;
- incorporate the 401 Water Quality Certification Program into the Wetlands Protection Program;

- develop and conduct a Public Education and Training Program;
- develop wetland water quality standards;
- assess levels of compliance with Wetlands Protection Permitting process;
- develop regulations for the 401 Water Quality Certification Program;
- develop and conduct a pilot "Circuit Rider" approach to providing technical assistance to Conservation Commissions;
- assess most commonly employed methods to delineate wetland boundaries;
- develop and conduct wetland delineation training workshops.

These grants have been awarded to the Division over the past five years and the projects listed above are in various stages of completion. A brief status report for each project is provided below.

Two-tier Assessment

The July 1995 Progress Report from UMASS Principle Investigators indicate the Economic component of this project is complete and an annotated outline of the Wetland Assessment methodology has been drafted. UMASS anticipates the project will be completed by Spring 1996.

401 Water Quality Certification Transfer and Regulation Development

The incorporation of the 401 WQC process into the Wetlands Protection Program was completed in October 1992. A final report detailing DEP activities in this process was distributed in September 1993. A Permit Tracking Management System which includes the 401 Tracking system is operational in DEP Regional Offices. This project has been completed.

Public Education and Training

Documents completed to date include: Wetlands Report newsletters and Wetlands Report Alert; BVW delineation handbook; BVW workshop brochure; overheads for Forestry workshops; Illustrations for educational documents; and Forestry Chapter to Agriculture Manual. Additionally, bids for editing the general wetlands informational video have been solicited. Other documents being developed and their projected completion date include:

-- General Wetlands Brochure/Summer 1996;
-- MA Wetlands Protection Laws Brochure/Summer 1996; and
-- Wetlands Public Interest Booklet/Summer 1996.

Wetland Water Quality Standards

Coordination between DEP and federal agencies culminated in the issuance of a programmatic general permit (PGP) for Army Corp of Engineers projects. Under the PGP the amount of wetland filling proposed determines the level of federal review. Projects filling under 5,000 square feet can proceed without federal review. Additionally, the new State Regulations for 401 Water Quality Certification process that took effect on March 15, 1995 increase wetland protection by prohibiting discharge of fill into ORWs and by requiring an Alternative Analysis for filling more than 5,000 square feet of federal wetlands including BVW and Isolated Wetlands. This project has been completed.

Non-Compliance with Wetland Protection permitting process

Random sample of Wetland Protection permits in the Northeast Region were reviewed to determine compliance with the permitting process. Survey indicated that the presence of a Conservation Agent increased effectiveness and compliance. Study revealed need for targeted technical assistance to address town specific needs. The Final Report was distributed and this project has been completed.

401 Water Quality Certification - Regulation Development

401 Water Quality Certification regulations were promulgated effective March 1995. Workshops for Conservation Commission, State Agency staff, and Consultants were conducted and the project was completed.

Circuit Rider - Phase I and Phase II

A Circuit Rider was hired in May 1995 and a Work plan developed. Towns in lower Housatonic River watershed have been contacted and meetings/workshops with town officials conducted on map reading, plant identification, and boundary delineation.

BVW Delineation Methodology Survey

Survey indicated majority of commissioners use "visual estimates" based on wetland plant species and site specific observations such as slope, topography and hydrology to delineate or verify wetland boundaries. Hydric soils used by relatively few commissions. Study indicated need for more hands-on BVW delineation training. The final report was distributed and the project was completed.

BVW Delineation Training

Classroom sessions with approximately 850 attendees were conducted in March, April and May, 1995. Seven full day field sessions were offered in May and June with over 250 attendees. One field session specifically for state agency staff was held in September. Three full day field workshops with over 200 attendees were conducted in November. Additional workshops during the winter months are also planned. Materials including soil charts, and hydric soils books were purchased for distribution to Commissions.

7.0 GROUNDWATER ASSESSMENT

7.1 Groundwater Discharge Permit Program

The Massachusetts Groundwater Discharge Permit Program and the Massachusetts Groundwater Quality Standards were established by the Department of Environmental Protection to protect all groundwater of the Commonwealth. These two regulations are identified as Title 314 of the Code of Massachusetts Regulations, Chapters 5.00 and 6.00 respectively. Major features of the regulations include a state-wide groundwater classification program and groundwater discharge permit enforcement authority. Under the former, a mechanism has been created for other classification of the Commonwealth's groundwater with respect to protecting its most sensitive use. The three classes of groundwater are:

Class I: Fresh groundwater found in the saturated zone of unconsolidated deposits or unconsolidated rock and bedrock are designated as a source of potable water supply.

Class II: Saline waters found in the saturated zone of the unconsolidated deposits or consolidated rock and bedrock are designated as source of potable mineral waters, for conversion to fresh potable waters, or as raw material for the manufacture of sodium chloride or its derivatives or similar products.

Class III: Fresh and Saline waters found in the saturated zone of unconsolidated deposits or consolidated rock and bedrock and are designated for uses other than that as a source of potable water supply. At a minimum, the most sensitive use of these waters is as a source of non-potable water which may come in contact with, but is not ingested by humans.

Under 314 CMR 6.00, individuals desiring a particular classification for a groundwater were given until January 1, 1985 to submit a petition of request to the Department. The Department reviewed all requests received and assigned four limited Class III designations. Groundwater for which no specific classification petitions had been received were designated as Class I, thereby affording protection to the most sensitive use - drinking water supply.

Reclassification may also be initiated by a petition which can be accepted at any time. All petitions must include certain minimum information including a description of the existing groundwater quality, current and potential uses of the groundwater, identification of potentially affected water supplies, and a statement of needs. Petitioners may also be required to submit a hydrogeologic study. The required detail of this study will depend on the complexity of the area's geology and hydrology, the potential environmental impacts and an economic analysis of upgrading discharge treatment to Class I standards.

Standards for granting a Class III designation include the following:

1. The groundwater impacted by the classification is under single ownership by the discharger proposing the classification; or

2. The groundwater affected by the classification is not a present or potential source of drinking water because:

a) the depth of location of the groundwater makes its use as drinking water economically or technologically infeasible; or
b) the groundwater is sufficiently contaminated to make its recovery for drinking water use economically or technologically infeasible; or

c) the discharge is located over a federally-defined Class III well mining area subject to subsidence or catastrophic collapse; or

3. The groundwater affected is a potential source of drinking water, but an alternate source is available and will be provided by the discharger proposing the classification to all existing and potential users of the aquifer affected by the discharge.

Furthermore, once all the above have been fully satisfied, the state will consider potential adverse effects on hydrologically connected surface and groundwater. The state must take into account future as well as present uses of adjacent water and groundwater.

Currently, the protection of groundwater from point sources of pollution is accomplished through the Department's Groundwater Discharge Permit Program administered by the Division of Watershed Management. All dischargers of industrial pollutants and dischargers of over 15,000 gallons per day of sanitary wastewaters into the groundwater require a groundwater discharge permit. This includes, but is not limited to: facilities discharging a liquid effluent below the land surface or into a percolation pit, pond or lagoon; facilities discharging a liquid effluent into leaching pits, galleries, chambers, trenches, fields and pipes; facilities discharging a liquid effluent into an injection well; any facility with an unlined pit, pond, lagoon or surface impoundment in which wastewaters or sludges are collected, stored, treated or disposed of; or conveyances that collect and convey stormwater runoff contaminated by contact with process wastes, raw materials, toxic pollutants, hazardous substances or contact with a leaching facility. Some existing facilities and all new facilities with sanitary wastewater discharges over 10,000 gallons per day also require a groundwater discharge permit. Groundwater discharges from waste site remediation systems which operate in accordance with the Massachusetts Contingency Plan, 310 CMR 40, are exempt from having to obtain a permit.

Discharges to Class I and Class II groundwater must meet the more stringent of either the technology standards or the national primary and secondary drinking water standards. U.S. EPA and State Health Advisories are used as effluent concentration guidelines. Compounds which are considered toxic and for which there is neither a water quality standard nor a health advisory, are prohibited from discharge.

The discharge of sanitary wastewater in excess of 15,000 gallons-per-day requires a minimum of secondary wastewater treatment or its equivalent. All industrial process wastewater discharges are required to meet technology standards and the proposed treatment system must receive Department approval. These measures serve to ensure that the permitted discharge will be in compliance with Class I or Class II standards.

Discharge to Class III groundwater must also meet the more stringent of technology standards or water quality standards, but water quality standards for Class III groundwater are determined on a case-by-case basis and are generally less stringent than those for Class I or Class II aquifers. Water quality standards for Class III groundwater are determined based upon two most sensitive identifiable water uses. At a minimum, Class III groundwater must meet water quality criteria based upon human exposure limits.

In Massachusetts, each permit contains monitoring requirements to assure compliance with permit limitations and conditions. The Department determines the number of wells (a minimum of one up gradient and two down gradient), location, dimensions, method of construction, and frequency of reporting on a case-by-case basis. The State has established guidelines for making these determinations, and the guidelines vary according to the type of facility and the aquifer type under consideration. For Class I and Class II groundwater, most of the monitoring will occur at the point where the effluent emerges from a treatment works, disposal system, outlet or point source prior to being discharged into the ground. For Class III groundwater, the state will require monitoring between the point source and the compliance boundary.

An integral part of the groundwater discharge permit program is the permit review process which may encompass many of the divisions within the Department such as Water Supply, Water Pollution Control, Hazardous Waste, and the Wetlands and Waterways. The review process ensures that the environmental concerns particular to each Division within the Department are considered and addressed.

Authority granted under the Administrative Penalty Statute allows the Division to assess civil penalties up to $25,000 per day of violation per violation of permit limitations as well as unpermitted discharges. This program has proven to be a very effective tool in addressing non-compliance cases as well as providing an extra incentive to permittees to maintain compliance.

The majority of groundwater discharge permits issued to date are for sanitary sewage discharged to the ground by small privately owned sewage treatment facilities. The total discharge flow rate is approximately 15 million gallons per day. The responsibility for industrial discharges lies with the Bureau of Waste Prevention, Industrial Waste Section.

7.2 Other Groundwater Water Quality Issues

In addition to municipal and privately owned wastewater treatment facilities, over 650,000 individual subsurface sewage disposal systems (septic systems), serving approximately 30 percent of the population, mostly in rural areas operate in the Commonwealth. Title 5 of the State Environmental Code (310 CMR 15.00) sets minimum design and siting criteria for individual subsurface disposal systems. Under the appropriate environmental conditions, these on-site systems can provide a safe and effective means of sanitary waste disposal, particularly in areas of low density development.

However, water quality impacts to both municipal and private drinking water supplies have been documented in densely populated areas which rely on septic systems. Wastewater treatment, even on the level of the individual home system, must be designed and regulated to protect groundwater resources. Recent revisions to Title 5 further address this goal.

Septic systems along with wastewater treatment facilities, industrial facilities, restaurants and commercial facilities produce residual waste. Conventional disposal methods such as incineration and landfilling have proven to be both ineffective and expensive. New technologies and methods, such as composting for beneficial uses, are being developed, evaluated and implemented. This may require both administrative and regulatory changes. In addition, waste constituents, particularly toxics, which make residuals so difficult to treat and dispose of properly must be better managed at the source. The recently enacted Toxics Use Reduction Act and the existing

industrial pretreatment program are expected to provide relief over the long term.

7.3 Groundwater Quantity Issues

During 1990, groundwater withdrawals totaled 329 million gallons per day and accounted for 24 percent of the total water withdrawals in Massachusetts. The Charles River basin had the largest amount of groundwater withdrawals. This is due to the fact that although the Massachusetts Water Resource Authority serves metropolitan Boston from the Quabbin and Wachusett Reservoirs, suburban Boston is served only by groundwater sources. The Cape Cod River Basin had the second largest amount of groundwater withdrawals.

Public water supply accounted for the largest percentage (54 percent or 179 mgd) of all groundwater withdrawals. Public supply water is water withdrawn by public and private water suppliers who provide water to various domestic, commercial and industrial users as well as thermoelectric power plants. Industrial was the next highest use accounting for 17 percent (56.3 mgd) of all groundwater withdrawals. This water is used in fabricating, processing, washing and cooling industrial materials. Commercial withdrawals (55.2 million gallons per day) account for 17 percent of all groundwater withdrawals. Commercial water is used in motels, hotels, restaurants, office buildings and other commercial facilities, plus institutions, such as hospitals or schools. Water withdrawn for air conditioning and fish hatcheries is also included. Domestic withdrawals include water used for drinking, preparing food, bathing, washing clothes or dishes, flushing toilets and watering lawns and gardens. Domestic withdrawals (36.8 mgd) accounted for 11 percent of all groundwater withdrawals.

7.4 Causes and Sources of Pollution

There are many sources and types of ground water contamination. Pollutants can seep into groundwater from hazardous waste sites, poorly constructed landfills or septic systems. Groundwater can also be polluted by runoff from urban areas, salted roads and industrial facilities. Gasoline and other harmful substances can leak from underground storage tanks to the groundwater supply. The most prevalent contaminant group from these activities is volatile organic compounds (VOCs). Table 7.1 presents the major sources of contamination to groundwater which were compiled by the Division of Water Supply while Table 7.2 presents a summary of the types of contaminated sites in Massachusetts.

Massachusetts has several efforts focusing on groundwater protection efforts. Considerable data is collected by the Bureau of Waste Site Clean Up through its Chapter 21E program, the Division of Solid Waste, by cities and towns reporting water quality data of public supplies to the Division of Water Supply and by permittees on regulated discharges. Table 7.3 lists the various programs and their programmatic activity.

TABLE 7.1

MAJOR SOURCES OF GROUNDWATER CONTAMINATION

CONTAMINATION SOURCE	FACTORS CONSIDERED IN SELECTING A CONTAMINANT SOURCE	CONTAMINANTS
Storage tanks (underground)	A,D,B,C,E,F	1,2,10
Landfills	A,D,B,E,F,C	1,2,3,5,7,9,10
Septic systems	A,C,D,B	3,7,8,9,10
Hazardous waste generators	A,D,B,E	1,2,5,6,7,9,10
Hazardous waste sites	A,D,B,E,F	1,2,5,6,7,9,10
Industrial facilities	A,D,B,E,C,F	1,2,5,6,7,9,10
Pipelines and sewer lines	A,B,C,D	1,3,5,7,9,10
Salt storage and road salting	D,C,A,B	4
Spills	A,B,E	1,2,10
Urban runoff	A,C,D,B,E	1,2,4,10

Key to Factors and Contaminants

A. Human health and/or environmental risk (toxicity)
B. Size of the population at risk
C. Location of the sources relative to drinking water sources
D. Number and/or size of contaminant sources
E. Hydrogeologic sensitivity
F. State findings, other findings

1. Halogenated solvents
2. Petroleum compounds
3. Nitrate
4. Salinity/brine
5. Metals
6. Radionuclides
7. Bacteria
8. Protozoa
9. Viruses
10. Volatile Organic Compounds

TABLE 7.2

STATEWIDE GROUNDWATER CONTAMINATION SUMMARY
1993 - 1995

SOURCE TYPE

	NPL	CERCLIS (non-NPL)	DOD/DOE	LUST	RCRA CORRECTIVE ACTION	UNDERGROUND INJECTION	21E STATE SITES
Number of sites in area	31	300	322	404	157*		3908
Number of sites that are listed and/or have confirmed releases	31	Unknown	35	349	35	230	
Number with confirmed groundwater contamination	9			68	28	106	
Contaminants	VOCs, IOC				VOCs, Metals, Petroleum	VOC, TPH, Metals	All
Number of site investigations	31			317**	35	789	
Number of sites that have been stabilized or have the source removed	21			276**	27	558	
Number of sites with corrective action plans	24				6	309	
Number of sites with active remediation	31				5	61	
Number of sites with cleanup completed	4			343**	8	248	

NPL - National Priority List
CERCLIS (non-NPL) - Comprehensive Environmental Response, Compensation, and Liability Information System
DOE - Department of Energy
DOD - Department of Defense
LUST - Leaking Underground Storage Tanks
RCRA - Resource Conservation and Recovery Act
*An unknown number of these RCA facilities are being address by MA 21E Program.
**Running totals (may incorporate cases from previous years).

TABLE 7.3

SUMMARY OF MASSACHUSETTS GROUNDWATER PROTECTION PROGRAMS

PROGRAMS OR ACTIVITIES	IMPLEMENTATION STATUS	RESPONSIBLE STATE AGENCY
Active SARA Title III Program	fully established	DEP
Ambient groundwater monitoring system	fully established	DEP
Aquifer vulnerability assessment	fully established	DEP
Aquifer mapping	continuing efforts USGS/DEP	
Aquifer characterization	continuing efforts USGS/DEP	
Comprehensive data management system	under development	DEP
EPA-endorsed Core Comprehensive State Groundwater Protection Program (CSGWPP)	fully established	DEP
Groundwater discharge permits	fully established	DEP
Groundwater Best Management Practices	fully established	DEP
Groundwater legislation	fully established	DEP
Groundwater classification	continuing efforts	DEP
Groundwater quality standards	fully established	DEP
Interagency coordination for groundwater protection initiatives	fully established EOEA/DEP	
Nonpoint source controls	fully established	DEP
Pesticide State Management Plan	under development	DFA
Pollution Prevention Program	fully established	DEP
Resource Conservation and Recovery Act (RCRA) Primacy	fully established	DEP
State Superfund	fully established	DEP
State RCRA Program incorporating more stringent requirements than RCRA Primacy	fully established	DEP
State septic system regulations	fully established	DEP
Underground storage tank installation requirements	fully established	DPS
Underground Storage Tank Remediation Fund	under development	DPS
Underground Storage Tank Permit Program	N/A	-
Underground Injection Control Program	fully established	DEP
Vulnerability assessment for drinking water/wellhead protection	fully established	DEP
Well abandonment regulations	fully established	DEP
Wellhead Protection Program (EPA-approved)	fully established	DEP
Well installation regulations	under development DEP/DEM	

DEP - Department of Environmental Protection
USGS - United States Geological Survey
EOEA - Executive Office of Environmental Affairs
DFA - Department of Food and Agriculture
DPS - Department of Environmental Management

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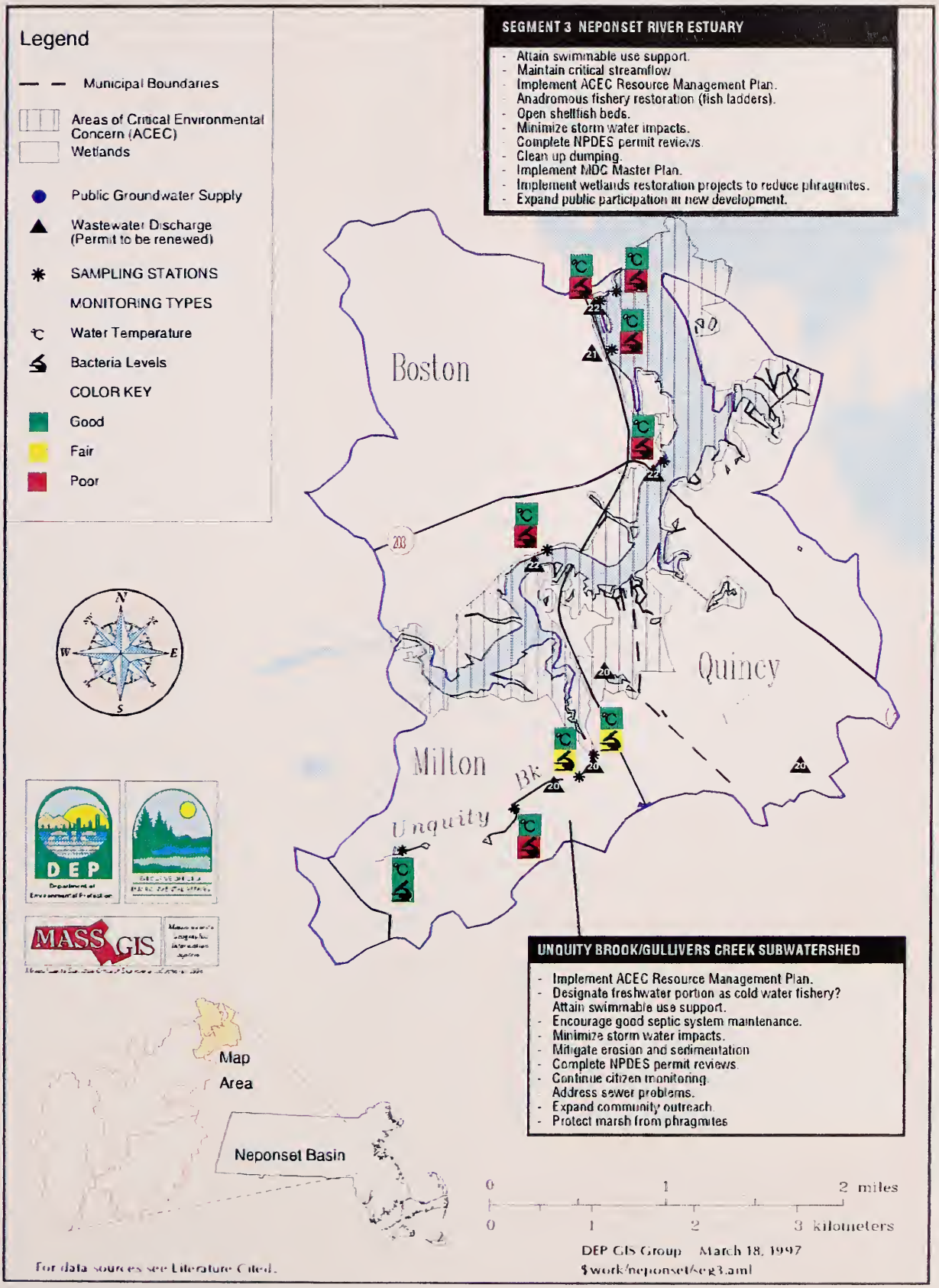
Attachment No. 1

Neponset River Watershed Monitoring Project



The Neponset River Watershed 1996 Basin-Wide Action Plan. The Neponset Estuary (DEP Segment 3).

Active Stream Teams include: Friends of the Neponset Estuary (Estuary and Unquity Brook / Gullivers Creek Subwatershed).

SS. EA 22.2: C73/998

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COMMONWEALTH OF MASSACHUSETTS

SUMMARY OF WATER QUALITY

1998

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